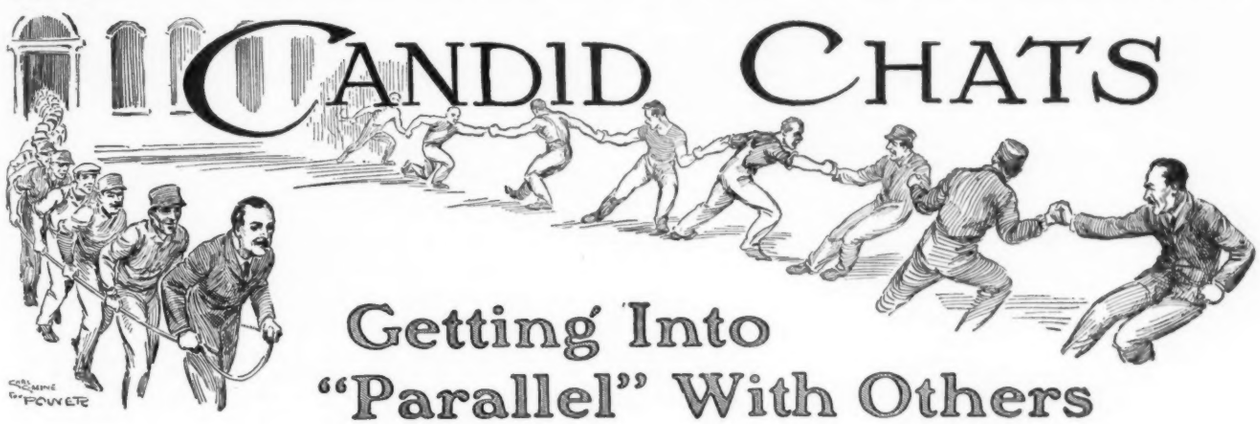
POWER

Vol. 45 NEW YORK, MAY, 29, 1917 No. 22



Getting Into "Parallel" With Others

GENERATORS, lamps, motors and men perform their most useful service when working in "parallel."

"Series" connections are the exception.

Here is a valuable lesson for the ambitious engineer.

"Parallel" operation is team play translated into electrical language.

Look at the series lighting circuit. Either a special generator or a "tub" transformer must be provided at the station, with a switchboard investment useless for any other class of service. Out on the line the same lack of electrical democracy prevails. For sheer exclusiveness the "series" lighting outfit beats everything on the distribution system. It passes by on the other side when it sees a would-be power user, and even the two wires that mark its pathway often refuse to occupy adjacent insulators on the same crossarm. As an example of pure individualism such a circuit cannot be surpassed. Every lamp in normal operation takes the same current as every other, and if a lead wire to a single bracket-arm parts, out goes every unit.

Consider the "parallel" circuit. In the station, each generator runs in synchronism with every other in service, taking a share of the load proportioned to its capacity. If one machine has to be shut down, another is usually on hand to take its place without interruption of service. Out of the plant run the distribution wires. Whether single, "two" or three-phase, or of the direct-current type, parallelism controls. A tap here, another there, and so it goes. A motor in this place, a group of lamps in the next, up to the limits of good regulation, and all this without materially affecting the service of other equipment supplied from the same feeder. A better example of co-operation would be difficult to find.

Some men are of the "Series" type.

From their first day on the job to their last, they always have to be told what to do. They think other men's thoughts after them, depend upon the originality of their superiors and associates and are literally the weakest links in the local chains. They have no conception of professional association, regard progressive fellow-employees with suspicion and never learn to get "into step" with their mates. Sluggish in their mental habits, jealous of petty prerogatives, they wonder why their pay envelopes never grow thicker. Middle life finds them fast-fixed in their ways, hostile toward new things, skeptical in the face of new propositions and altogether to be pitied for their incapacity and conservatism.

Most of us start our careers in "series" with some superior mind, just as the motors of the electric car have to be protected from over-voltage when the run begins. But as fast as the resistance of inexperience and ignorance is cut out, the higher the safe pressure applied, until finally, full speed ahead demands parallel operation, every motive agency taking maximum line voltage. The analogy holds all the way along. The man that can work in harmony with others, synchronizing his efforts with theirs, adding his energy to that of the other members of the staff and realizing that getting "out of step" and "bucking the line" are as harmful for him as they are injurious to the service of the organization as a whole, is the type of employee always specified in building new staffs, who carries the responsible loads of the world and reaps the just reward of knowing how to work in "parallel" with other human "units" of varying capacity, speed and efficiency.

Contributed by H. S. KNOWLTON, *Cambridge, Mass.*

Entropy and Some of Its Uses—I

By F. R. Low

In the introduction to his book, "The Energy Chart," Capt. H. Riall Sankey gives a conception of entropy which anybody can understand. In Fig. 1 let the base line *OX* represent the absolute zero of temperature and let the point *A* represent by its height above this base the temperature 32 deg. F. (492 deg. absolute). Let the point *B* represent 33 deg. F., and let the area *ABFEA* represent the heat necessary to raise a pound of water from 32 to 33 deg. This rise would be $^1/_{492}$ of the height *AE*, (32 + 460) = 492 being the absolute temperature of the freezing point of water.

Now let the pound of water be raised in temperature another degree, and indicate this temperature by the height of the point *C*, one degree higher to the same scale.

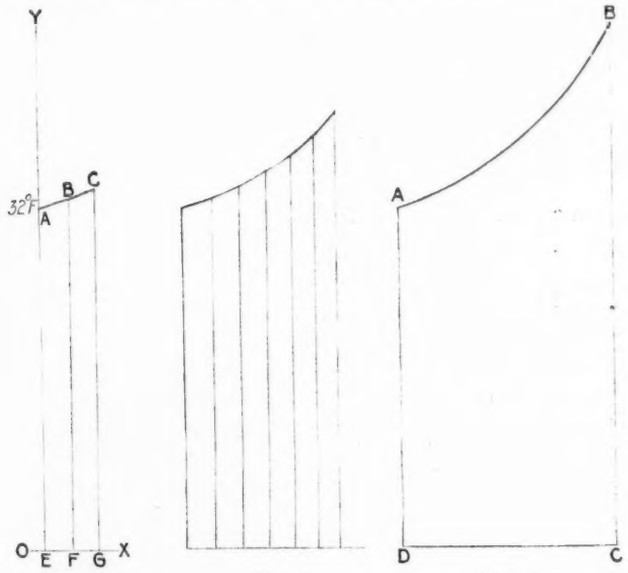


Fig. 1

Fig. 2

Fig. 3

FIGS. 1 TO 3. FORMATION OF THE WATER LINE

The area *BCGFB* must represent the heat necessary to raise the pound of water through this degree, which amount of heat is about the same as that required to raise it from 32 to 33; but since this section is a trifle higher, it will, in order that it may have the same area, be a trifle narrower than the first, and the line *BC* will have a little steeper slant than has *AB*.

If successive rises of one degree each were added, some such effect would be reproduced as in Fig. 2, and if the rises were by very small steps, or increments, instead of by full degrees, the line would smooth out into a curve, as in Fig. 3. Any point, as *B*, Fig. 3, upon this line represents by its height an absolute temperature, and the area under the curve up to that point, as *ABCDA*, is proportional to the amount of heat required to raise a pound of water (in case the diagram is being drawn for water) from 32 deg. to the temperature corresponding to the height of *B* above the base-line.

Suppose the temperature of the pound of water to be raised to 360 deg. F. The area *h*, Fig. 5, will represent the amount of heat necessary to raise it to this temperature from 32 deg. This is usually referred to as the "heat of the liquid" and is given in the steam table, Fig. 4, in the column marked "*h* or *q*."

Suppose the pressure to be such that at 360 deg. the water begins to boil. The heat now absorbed is used up in changing the water into steam and does not increase its temperature. It is referred to as the "latent heat of evaporation." The amounts required to evaporate one pound of water from and at given temperatures are given in the steam table, Fig. 4, in the column marked "*L* or *r*." The change of state under constant temperature takes place along the line *BC*, Fig. 5, the height of which, above the base-line, is constant, and the length *BC* of which is such that that the area *BCDEB* under it is proportional to the latent heat as given in the steam table.

We have now a diagram *ABCDFA*, Fig. 5, the total area of which is proportional to the total energy required (in the form of heat) to raise a pound of water from 32

Table 1: Temperatures

Temp. Fahr. t	Pressure lbs. p	Pressure Atmos* —	Sp. Vol. cu. ft. per lb. v or s	Density lbs. per cu. ft. 1/v	Heat of the liquid h or q	Latent heat of evap. L or r	Total heat of steam H	Internal Energy B. t. u. Evap. I or ρ	Internal Energy B. t. u. Steam E	Entropy Water n or φ	Entropy Evap. L/T or r/T	Entropy Steam N or ϕ	Temp. Fahr. t
330°	103.0	7.01	4.306	0.2322	300.6	886.3	1186.9	804.8	1105.0	0.4771	1.1225	1.5996	330°
331	104.4	7.11	4.250	0.2353	301.6	885.5	1187.1	803.9	1105.2	0.4784	1.1200	1.5984	331
332	105.9	7.21	4.195	0.2384	302.7	884.7	1187.4	803.1	1105.4	0.4797	1.1176	1.5973	332
333	107.4	7.31	4.141	0.2415	303.7	883.9	1187.6	802.2	1105.6	0.4810	1.1152	1.5962	333
334	108.8	7.40	4.088	0.2446	304.7	883.1	1187.8	801.4	1105.8	0.4824	1.1127	1.5951	334
335°	110.3	7.50	4.035	0.2478	305.8	882.3	1188.1	800.5	1106.0	0.4837	1.1103	1.5940	335°
336	111.8	7.61	3.984	0.2510	306.8	881.5	1188.3	799.7	1106.1	0.4850	1.1079	1.5929	336
337	113.4	7.72	3.934	0.2542	307.9	880.7	1188.6	798.8	1106.3	0.4863	1.1055	1.5918	337
338	114.9	7.82	3.884	0.2575	308.9	879.9	1188.8	798.0	1106.5	0.4876	1.1032	1.5908	338
339	116.4	7.92	3.835	0.2608	309.9	879.1	1189.0	797.2	1106.7	0.4889	1.1008	1.5897	339
340°	118.0	8.03	3.787	0.2641	311.0	878.3	1189.3	796.3	1106.9	0.4902	1.0984	1.5886	340°
341	119.6	8.14	3.739	0.2675	312.0	877.5	1189.5	795.4	1107.0	0.4915	1.0961	1.5876	341
342	121.2	8.25	3.692	0.2709	313.0	876.7	1189.7	794.6	1107.2	0.4928	1.0937	1.5865	342
343	122.8	8.36	3.646	0.2743	314.1	875.9	1190.0	793.7	1107.4	0.4941	1.0913	1.5854	343
344	124.4	8.47	3.600	0.2778	315.1	875.1	1190.2	792.9	1107.6	0.4954	1.0889	1.5843	344
345°	126.0	8.58	3.555	0.2813	316.2	874.2	1190.4	792.0	1107.8	0.4967	1.0875	1.5832	345°
346	127.7	8.69	3.511	0.2848	317.2	873.4	1190.6	791.2	1108.0	0.4980	1.0841	1.5821	346
347	129.4	8.80	3.468	0.2884	318.3	872.6	1190.9	790.3	1108.1	0.4993	1.0818	1.5811	347
348	131.1	8.92	3.425	0.2920	319.3	871.8	1191.1	789.4	1108.3	0.5006	1.0794	1.5800	348
349	132.8	9.04	3.383	0.2956	320.3	871.0	1191.3	788.6	1108.5	0.5019	1.0771	1.5790	349
350°	134.6	9.16	3.342	0.2992	321.4	870.1	1191.5	787.7	1108.6	0.5032	1.0748	1.5780	350°
351	136.3	9.28	3.301	0.3029	322.4	869.3	1191.8	786.8	1108.8	0.5045	1.0724	1.5769	351
352	138.1	9.40	3.261	0.3067	323.5	868.5	1192.0	786.0	1109.0	0.5058	1.0700	1.5758	352
353	139.9	9.52	3.221	0.3105	324.5	867.7	1192.2	785.1	1109.2	0.5071	1.0677	1.5748	353
354	141.7	9.64	3.182	0.3143	325.6	866.8	1192.4	784.2	1109.3	0.5084	1.0653	1.5737	354
355°	143.5	9.76	3.143	0.3182	326.6	866.0	1192.6	783.4	1109.5	0.5097	1.0630	1.5727	355°
356	145.4	9.89	3.105	0.3221	327.7	865.2	1192.9	782.5	1109.7	0.5110	1.0607	1.5717	356
357	147.2	10.02	3.067	0.3261	328.7	864.4	1193.1	781.6	1109.8	0.5123	1.0584	1.5707	357
358	149.1	10.15	3.030	0.3301	329.8	863.5	1193.3	780.8	1110.0	0.5136	1.0560	1.5696	358
359	151.0	10.28	2.993	0.3341	330.8	862.7	1193.5	779.9	1110.2	0.5149	1.0537	1.5686	359
360°	153.0	10.41	2.957	0.3382	331.9	861.8	1193.7	779.0	1110.4	0.5162	1.0514	1.5676	360°
361	154.9	10.54	2.922	0.3423	332.9	861.0	1193.9	778.1	1110.5	0.5174	1.0491	1.5665	361
362	156.9	10.68	2.887	0.3464	334.0	860.2	1194.1	777.2	1110.7	0.5187	1.0468	1.5655	362
363	158.8	10.81	2.853	0.3505	335.0	859.4	1194.4	776.4	1110.8	0.5200	1.0445	1.5645	363
364	160.8	10.94	2.820	0.3546	336.1	858.5	1194.6	775.5	1111.0	0.5213	1.0422	1.5635	364
365°	162.9	11.08	2.787	0.3588	337.1	857.7	1194.8	774.6	1111.1	0.5225	1.0400	1.5625	365°
366	164.9	11.22	2.754	0.3631	338.2	856.8	1195.0	773.7	1111.3	0.5238	1.0377	1.5615	366
367	167.0	11.36	2.722	0.3674	339.2	856.0	1195.2	772.8	1111.4	0.5251	1.0354	1.5605	367
368	169.0	11.50	2.690	0.3717	340.3	855.1	1195.4	771.9	1111.6	0.5263	1.0332	1.5595	368
369	171.1	11.64	2.658	0.3761	341.3	854.2	1195.6	771.0	1111.8	0.5276	1.0309	1.5585	369
370°	173.3	11.79	2.627	0.3806	342.4	853.4	1195.8	770.2	1111.9	0.5289	1.0286	1.5576	370°
371	175.4	11.93	2.597	0.3851	343.4	852.6	1196.0	769.3	1112.1	0.5301	1.0263	1.5564	371
372	177.6	12.08	2.567	0.3896	344.5	851.7	1196.2	768.4	1112.2	0.5314	1.0240	1.5554	372
373	179.7	12.23	2.537	0.3942	345.5	850.8	1196.4	767.5	1112.4	0.5327	1.0217	1.5544	373
374	181.9	12.38	2.508	0.3998	346.6	850.0	1196.6	766.6	1112.6	0.5340	1.0194	1.5534	374
375°	184.2	12.53	2.479	0.4034	347.6	849.1	1196.8	765.7	1112.7	0.5352	1.0172	1.5524	375°
376	186.4	12.68	2.450	0.4081	348.7	848.3	1197.0	764.8	1112.9	0.5364	1.0150	1.5514	376
377	188.7	12.84	2.422	0.4129	349.8	847.4	1197.2	763.9	1113.0	0.5376	1.0128	1.5504	377
378	190.9	12.99	2.394	0.4177	350.8	846.5	1197.4	763.0	1113.2	0.5389	1.0105	1.5494	378
379	193.2	13.15	2.367	0.4225	351.9	845.7	1197.5	762.1	1113.3	0.5401	1.0082	1.5483	379

* 1 atmo (standard atmosphere) = 760 mms. of Hg. by definition = 29.921 ins. of Hg. = 14.696 lbs. per sq. in.
For water, at 345° (120 lbs.), sp. vol., v' or σ = 0.0179 cu. ft. per lb.; 1/v' = 55.8 lbs. per cu. ft.; 144 Ap v' = 0.42 B.t.u.;
at 370° (179 lbs.), v' or σ = 0.0183 " ; 1/v' = 54.8 " ; 144 A v' = 0.69 "

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FIG. 4. REPRODUCTION OF A PAGE FROM THE MARKS-DAVIS STEAM TABLES

to 360 deg. and to evaporate it at that temperature. The heat thus represented is called the "total heat" and is given in the column marked "*H*" in the table of dry saturated steam. It is the sum of the heat of the liquid *h* and the latent heat of evaporation *L*. This en-

ergy is represented in B.t.u. by the area of the diagram, just as the energy developed by the steam in the cylinder of the engine is represented in foot-pounds by the area of the indicator diagram. See Figs 6 and 7. Height on the indicator diagram represents absolute pressure; on this newer diagram it represents absolute temperature. On the indicator diagram length represents volume, or the area of the diagram divided by the average height. On the other diagram it represents also the area divided by the average height—that is, the total heat divided by the average absolute temperature—and this horizontal dimension of a diagram such as Fig. 5, this ratio of the total heat to the average absolute temperature, is called "entropy." The diagram, Fig. 5 or 6, in which temperature is plotted in one direction and entropy in the other, is called the temperature-entropy diagram; just as the indicator diagram, in which pressures are plotted against volumes, is called the pressure-volume diagram. The Greek letter θ (theta) is commonly used as a symbol for temperature and ϕ (phi) for entropy, so that the temperature-entropy diagram is often referred to as the theta-phi diagram.

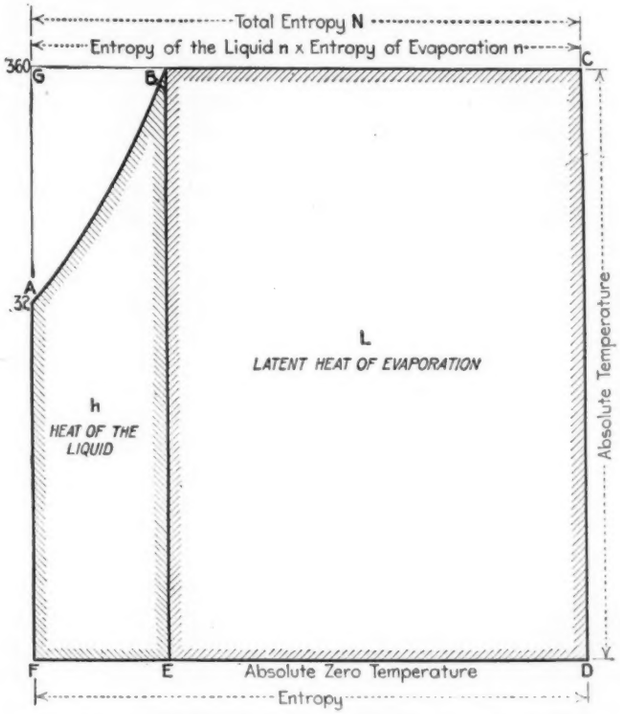


FIG. 5. TEMPERATURE-ENTROPY DIAGRAM FOR DRY-SATURATED STEAM

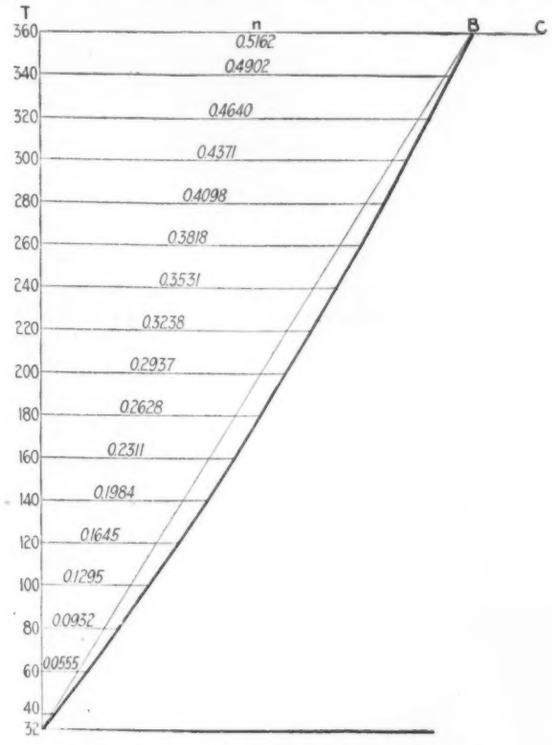
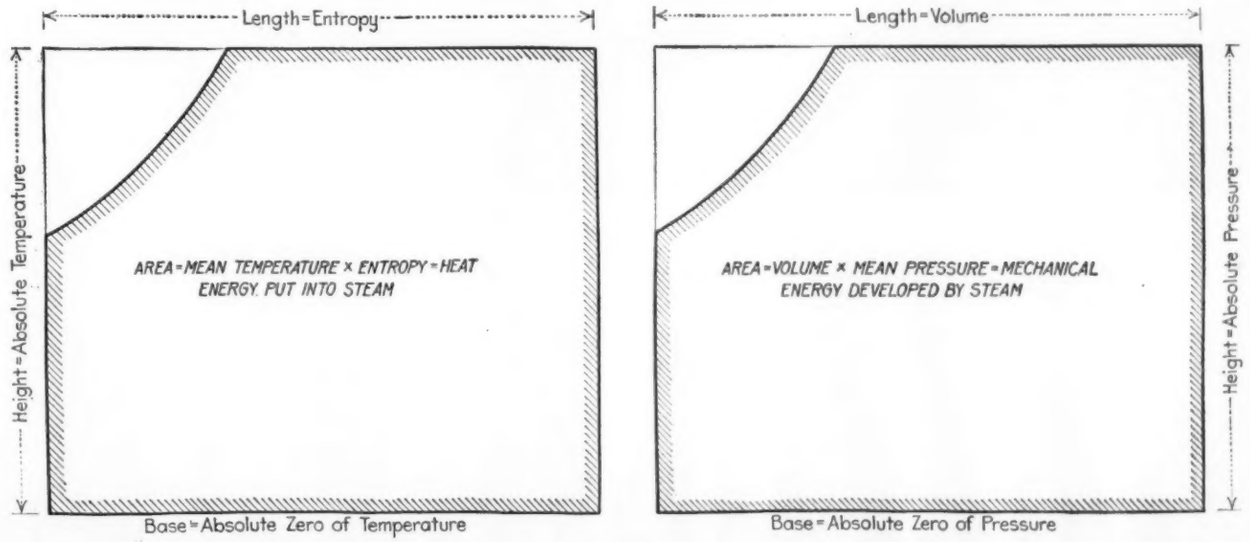


FIG. 8. PLOTTING THE WATER LINE

In the last three columns of the Marks-Davis tables of the properties of saturated steam (a page of which is reproduced in Fig. 4 with the permission of Longmans, Green & Co., their publishers) three values of entropy are given for each temperature—the entropy of the water, n; the entropy of evaporation, $\frac{L}{T}$ or $\frac{r}{T}$; and the entropy of the steam, N, which is the sum of the other two en-



FIGS. 6 AND 7. COMPARISON OF TEMPERATURE-ENTROPY AND PRESSURE-VOLUME OR INDICATOR DIAGRAMS

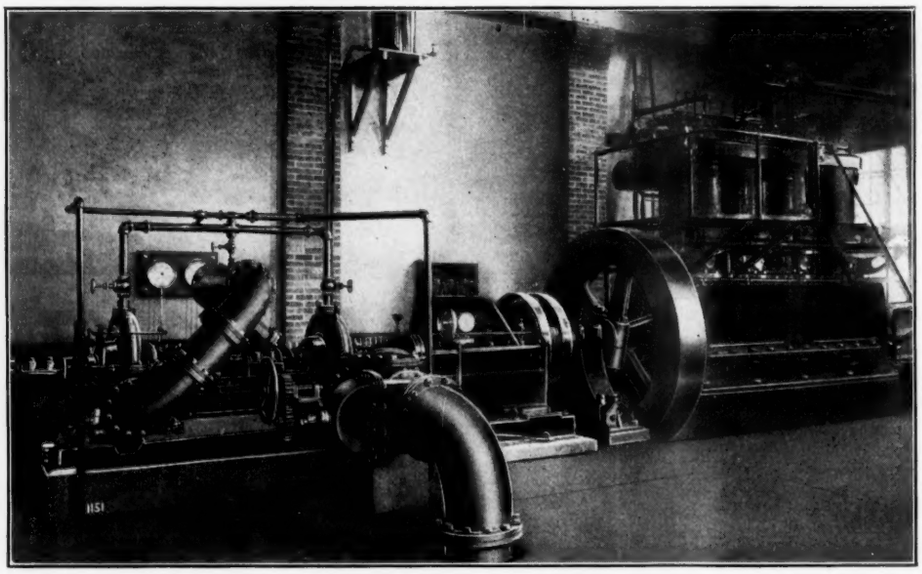
tropies. In Fig. 5, *GB* is the entropy *n* of the water at 360 deg., and *BC* the entropy of evaporation at that temperature. The rectangle *BCDEB*, representing the latent heat of steam at 360, is the product of the entropy *BC* and the absolute temperature *CD*. Hence the entropy is the quotient obtained by dividing the area by its height, or the ratio of the area to its height, $\frac{L}{T}$, or $\frac{r}{T}$, where *L* or *r* represents the latent heat of evaporation and *T* the absolute temperature. I shall use *n* for the entropy of the water, the Greek λ (lambda) for the entropy of evaporation, and *N* for their sum, or the entropy of the steam.

The reader will probably never need to lay out the diagram to scale, but that he may get a better idea of the significance of the tabular values of the entropies, I shall explain briefly how this may be done. To any convenient scale lay off horizontals at heights corresponding to a number of temperatures between 32 and the given higher temperature, as in Fig. 8. Then set off on these lines the entropies of the water for the respective temperatures. A scale of 20 deg. F. and 0.1 of a unit of entropy per inch will make a well-proportioned diagram and give 20 x 0.1 = B.t.u. per square inch of diagram. Fig. 8 was made with a scale of 1 in. = 40 deg. F. and 0.1 entropy, but has been reduced for printing. In the drawing the horizontals representing 20-deg. increments of temperature were ½ in. apart, and since the entropy of the water is 0.5162 at 360 deg., the position of the point *E* was determined by measuring out upon the horizontal at 360, 5.16 in. The points on the other lines were similarly determined and connected to form the curve. The diagram would be completed up to the state shown in Fig. 5 by putting in the base-line, 492 deg., below the 32-deg. point, to the same temperature scale, and extending the line *BC* to a length of 10.514 in., the entropy of evaporation at 360 being 1.0514.

Next week I shall show how some interesting problems can be simply solved by the use of entropy.

Gas-Engine-Driven Centrifugal Pumps

The pumping equipment recently put in service at Clarksburg, W. Va., consists of a 50-hp. Bruce-Macbeth gas engine driving through speed-increasing gears a 4,000,000-gal. per day De Laval centrifugal pump, which delivers water against 35 ft. head to the filter bed, and a 350-hp. gas engine running at 200 r.p.m., driving through double-helical speed-increasing gears a two-stage centrifugal pump, delivering 4,000,000 gal. per day against 350 ft. head to the city reservoir. The latter unit is illustrated herewith.



HIGH-PRESSURE GAS-ENGINE-DRIVEN PUMP

The gas engine was guaranteed by the maker to deliver a brake horsepower on 10 cu.ft. per hour of gas of a heat value of 1000 B.t.u. per cu.ft. During a ten days' continuous run the total consumption of the high-service and low-service pumps together was found to average 82,200 cu.ft. of gas per day. During this run the capacity was kept up to 4,100,000 gal. per day, the high-service pump delivering against about 330 ft. head, and the low-service pump against 30 ft. head, a total of about 258.5 water horsepower. The gas is received from wells near-by belonging to the city and is charged for at 6c. per 1000 cu.ft., although the commercial power rate in that locality is about 8c. The fuel cost of a water horsepower would be $6.96 per year at 6c. and $9.27 at 8 cents.

Formerly water was supplied by engine-driven centrifugal low-service pumps and duplex direct-acting high-service pumps, receiving steam from gas-fired boilers. With this equipment the gas consumption was about 350,000 cu.ft. per day, at a pumpage rate of approximately 3,000,000 gal. When additional capacity and new equipment became necessary, the Clarksburg Water and Sewage Board, and its engineer, George W. Fuller, made a careful investigation of the following: Steam-driven centrifugal pumps, steam-driven crank-and-flywheel pumping engines, gas-engine-driven direct-acting pumps and gas-engine-driven centrifugal pumps. The preliminary estimates showed that the best gas consumption with steam-driven pumps would be about three times that of gas-engine-driven pumps, and in view of the rapid depletion of the natural-gas supply in the neighborhood, it was deemed advisable to put in the more economical, although more expensive, equipment.

The complete cost of the pumping equipment was approximately $17,500. The cost of the substructure, superstructure, crane, piping and appurtenances complete was $13,905, or a total of $31,405. The annual interest, depreciation and upkeep charges on this amount at 8% would be $2512.40 per year, giving a total cost of pumping, exclusive of attendance and supplies, of $16.67 per water-horsepower-year of 365 days of 24 hours.

Organization of Government Machinery for War

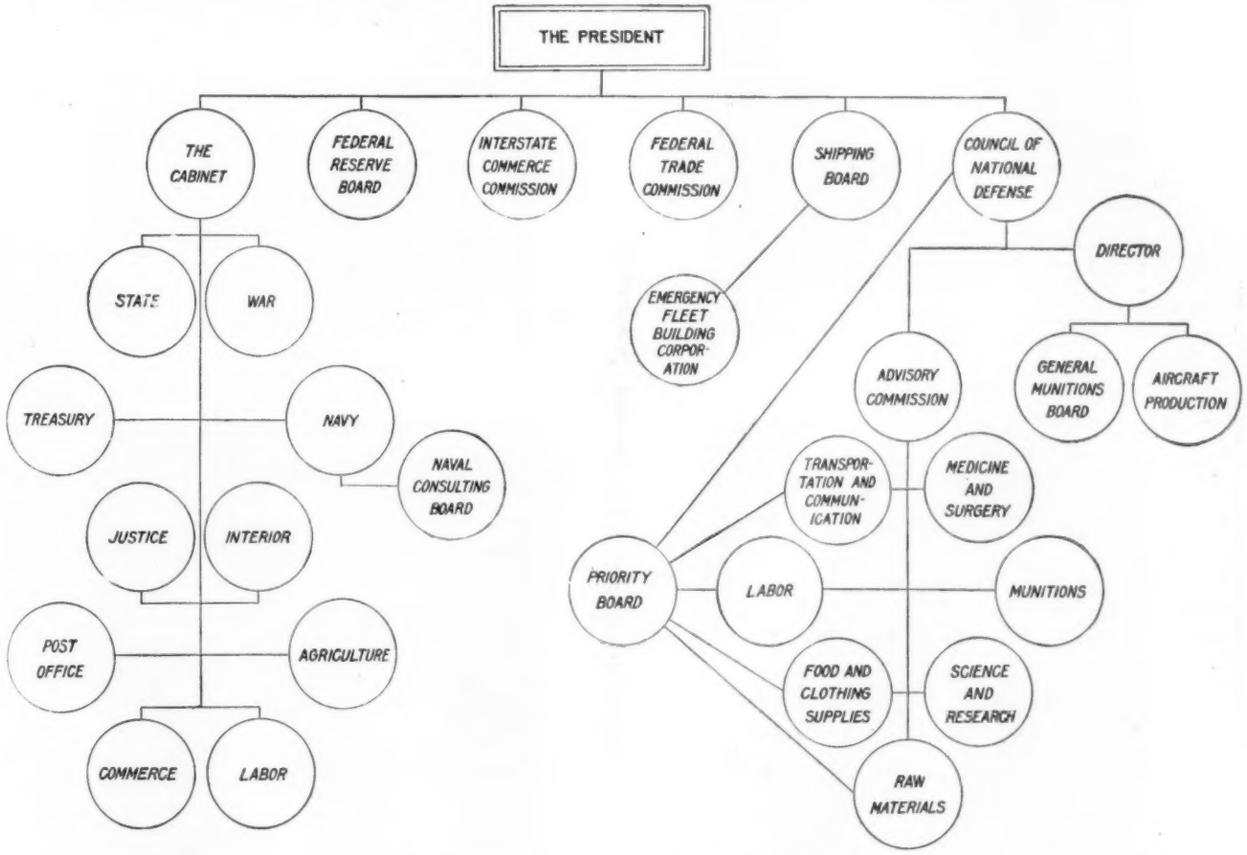
SYNOPSIS—Organization of various boards to supplement the regular Government bureaus in handling the tremendous work of preparing the country for war was necessary. A priority board to prevent much duplication and confusion will probably be added to coördinate the work of the various boards along lines shown by English experience to be most advisable.

President Wilson called it a war to make the world safe for democracy. Secretary of the Interior Lane, the other day, called it a test of the ability of this particular democracy, the United States, to organize itself out of and away from the dangers of economic anarchy.

The willingness to serve is abundant. Offers of ideas, offers of work, offers of material are flooding the National Capital. But the machinery for using it all in the way that will do the most good has not yet been perfected. It is a slow process. The indispensable thing is an agency for coördination, and that seems to be lacking.

Here is a case in point: Practically all the available steel of the country was offered to the Navy Department and accepted for the construction of big warships that are needed, but which cannot be finished for several years. This meant the diverting of steel from other industries, notably the building of railroad rolling stock and of merchant ships, to replace U-boat ravages, a diversion of material which has seriously handicapped the country in its work of feeding the Allies and making its own internal preparations for war. The steel should not have been turned over to the Navy Department but placed at the disposal of the Government to be parceled out in a more immediately effective way. And so with all classes of material and effort.

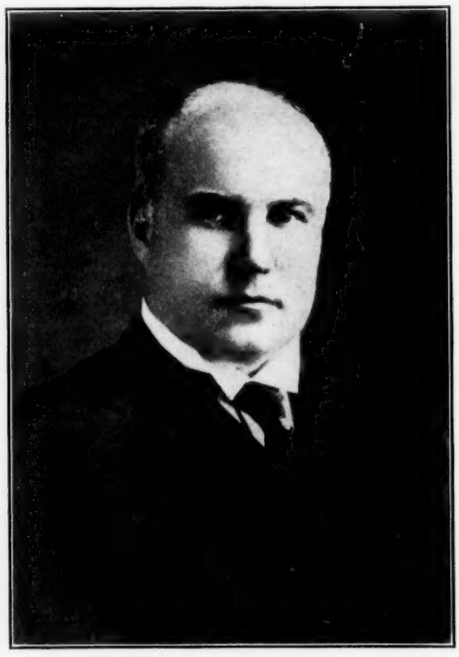
The accompanying chart from the New York *Times* indicates the present organization of the Government for war with one board or commission, called "Priority Board" in the diagram, which is not yet in the actual Government machinery, but which is very much needed there, according to Secretary Lane, who is one of the six Cabinet members constituting the Council of National Defense. Congress created this council. The President appointed the members of the Advisory Commission and then the council appointed the various committees making up the personnel of the seven main subdivisions of the commission. The Shipping Board, created by Congress last September, the Federal Trade Commission, the Federal Reserve Board, and the Interstate Commerce Commission, all have big war functions but are operating independently.



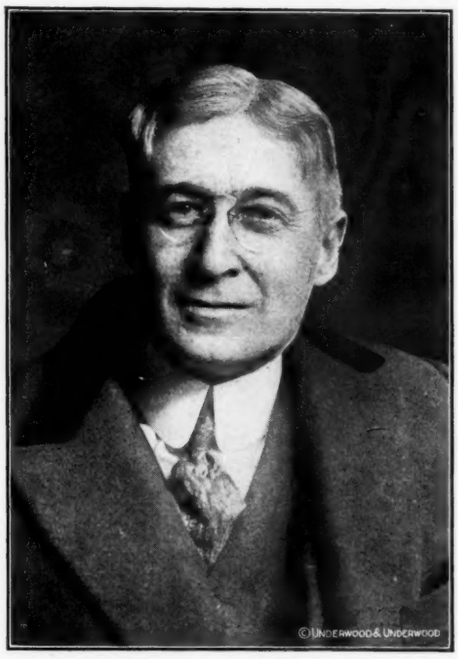
ORGANIZATION CHART, SHOWING RELATION AND COÖRDINATION OF GOVERNMENT WAR BOARDS

"It is a good organization," said Mr. Lane, "but we must have more complete coördination. England was finally obliged to establish its Priority Commission, the

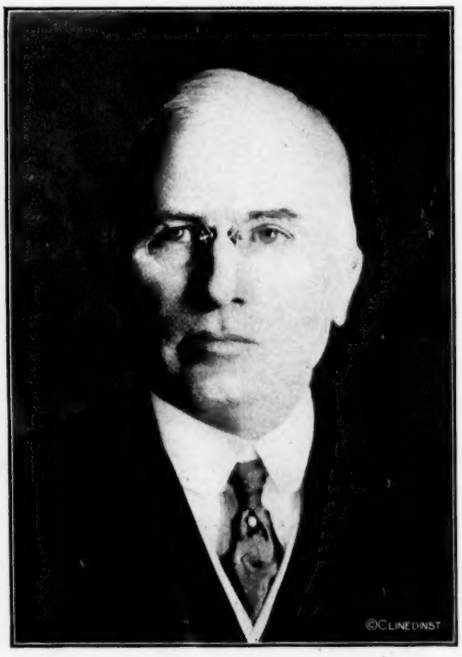
Secretary Lane and Three Members of the Advisory Commission of the Council of National Defense



FRANKLIN K. LANE
Secretary of the Interior



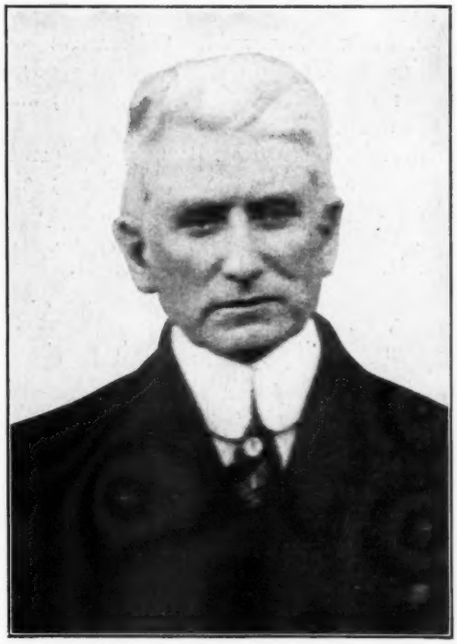
BERNARD M. BARUCH



DANIEL WILLARD
President, Baltimore & Ohio R.R.

HOWARD E. COFFIN
Vice President, Hudson Motor Car Co.

The Four Other Members of the Advisory Commission of the Council of National Defense



DR. FRANKLIN MARTIN
A distinguished surgeon of Chicago

JULIUS ROSENWALD
President, Sears, Roebuck & Co.

SAMUEL GOMPERS
President, American Federation of Labor

DR. HOLLIS GODFREY
President, Drexel Institute

name of which is self-explanatory, and we need a board with the same powers in this country. Such a commission is in touch with the needs of every department of government and of every essential industry. It administrates no activity of its own, but sees to it that no activity is crippled because of lack of supplies and labor due to such supplies or because of labor being wasted or used to lesser advantage by being deflected to where the need is not so great. It determines the distribution of ships, of railroad iron, of steel plates, of ammunition and machinery. It hears the arguments of the various departments with apparently conflicting demands and then decides each case in such a way as to serve the greatest good of the whole country and the greatest efficiency. It may be true that such a priority board cannot appreciate the needs of a given activity as well as the technical experts in that activity, but such a board can know the needs of all better than any special group can know them. It can coördinate. It is like the case of the thousand persons all striving to get through a narrow doorway at the same time. Only a few get through. The rest get hurt. Somebody must line them up and they will all get through in good order and in reasonable time.

"Group organization here is progressing rapidly, but the groups themselves must be tied into a whole machine abundantly lubricated with the oil of coördination. For example, the railroads organized for the war under a committee of the ablest railroad executives, who have interlocked the 250,000 miles of the country's railroads into a single coöperative system to eliminate wasteful competition and put the transportation of commodities and troops on the most effective war basis. But that does not go far enough. Beyond all that arises the question, what shall be shipped first, and in what quantities? The answer to that question should come from a priority board which knows what the most urgent need is at any given moment in any part of the world.

"Of course," said Secretary Lane, "we are just beginning in the United States on this work of broad-gage organization and coöperation. The war has waked us up to the necessity of it. It has shown beyond all question that a democracy cannot rest on economic anarchy."—*Engineering and Mining Journal.*

Advisory Commission to the Council of National Defense

WASHINGTON CORRESPONDENCE

Owing to the rapidity with which events have been moving during recent weeks, it is evident that considerable confusion exists as to the details of the organization of the Council of National Defense. The Council was authorized in the national defense act, which became a law Aug. 29. At its head are the Secretaries of War, Navy, Interior, Agriculture, Commerce and Labor. To serve with the secretaries is an advisory commission which serves without pay. Directly under the cabinet officers is a paid director and an administrative organization, which includes the secretary of the council and four assistants to the director, with their respective assistants. Immediately under the director, but not connected with the advisory commission, are the sections and boards of the council, of which the food board, under the direction of Herbert C. Hoover, and the committee on coal production, under the direction of F. S. Peabody, are examples.

The committees and coöperative committees are constituted as follows:

Transportation and communication, Daniel Willard. Coöperative committees on; telegraphs and telephones, T. N. Vail; railroads, Fairfax Harrison; electric railroads, Gen. George H. Harries.

Munitions, Howard E. Coffin. Coöperative committees on; national industrial conference, L. A. Osborne; public utilities, John W. Lied; industrial inventory, H. M. Lakeman; motor transport (unnamed).

Science and Research, Dr. Hollis Godfrey. Coöperative committees on; engineering societies (unnamed); education (unnamed).

Supplies, Julius Rosenwald. Coöperative committees on; cotton goods, Lincoln Grant; woolen goods, John P. Wood; shoes and leather, J. F. McElwain; knit goods, Lincoln Cromwell.

Raw materials, Bernard M. Baruch. Coöperative committees on; alcohol, Horatio S. Reubens; aluminum, Arthur V. Davis; asbestos, Thomas F. Manville; brass, Charles F. Brooker; coal tar products, W. H. Childs; lumber, R. H. Downman; lead, Clinton H. Crane; mica, L. W. Kingsley; nickel, Ambrose Monell; oil, A. C. Bedford; rubber, H. S. Hotchkiss; steel, Elbert H. Gary; sulphur, Henry Whiton; wool, Jacob F. Brown; zinc, Edgard Palmer; copper, John D. Ryan.

Labor, Samuel Gompers. Coöperative committees on wages and hours, F. Morrison; mediation and conciliation, V. Everit Macy; welfare work, L. A. Coolidge; women in industry, Mrs. Borden Harriman; information and statistics, F. L. Hoffman; press, Grant Hamilton; publicity, Dr. Edward T. Devine; cost of living, S. T. Ballard.

Operating a Series Motor with One Field Coil Removed

BY GORDON FOX

It may be of interest to relate the successful outcome of an endeavor to keep in operation an important motor that suddenly failed. The motor was operating the hoisting motion of a concrete distributing tower in connection with some building operations. A large number of men were dependent upon the operation of the motor, and a shut down was out of the question. Without warning, one day the motor suddenly grounded, and upon investigation it was found that one field coil was badly damaged. This coil had apparently been a little loose and, through magnetic pull, had chafed upon the polepiece, grounding with an arc that burned a large hole in the winding. The coil was wound with rectangular wire which could not be quickly secured, and there was no spare equipment suitable. It was soon evident that repairs to the defective coil would be hopeless.

It was decided to try operating the motor without any coil at all on this one polepiece. The motor was a series machine, so that removing one coil would not affect the other field coils, and it was reasoned that the result would merely be an increase in speed due to the weakened field. The defective coil was therefore removed and the bare polepiece inserted to provide the magnetic circuit which would be energized by the remaining coils. The motor was placed in service and found to operate almost exactly as before. It continued to carry its load without interruption for two weeks until a new coil arrived.

Practical Talks on Controllers—Lockout-Contactor Type*

SYNOPSIS—The operation of two types of controllers employing lockout and counter-electromotive-force types of contactors is explained. The limitations of the application of the lockout type of contactor are also discussed.

In considering the application of the lockout contactor it will be well to draw some comparison between it and the shunt type. The opening and closing of all contactors is dependent on the ampere turns of the operating coil; that is, the product of the current in amperes and the number of turns in the coil.

In the shunt contactor the coil is connected across a circuit the voltage of which is maintained practically constant. Hence for a given coil the ampere turns, or pull to effect closure, are constant, and such a contactor is manipulated by the opening and closing of the circuit to its coil. Consequently, the control of the circuit to the shunt coil must be accomplished by some switching device, such as individual hand-operated switches or a master drum switch; or, if automatically accomplished, by a relay, such a relay being responsive to the fluctuation of current in the main circuit; it may also be accomplished by a combination of both.

In the case of the lockout or series contactor the coil is connected in series in the main circuit, in which the

FIG. 1. CONTROLLER EQUIPPED WITH ONE COUNTER-E.M.F. AND TWO LOCKOUT CONTACTORS

current undergoes sudden fluctuations or gradual fluctuations, due to conditions in that circuit. Hence for a given coil, the ampere turns, or pull to effect closure, are varying with those fluctuations of current. This contactor is manipulated by diverting or directing the pull resulting from the ampere turns. The coil being in the main circuit, it is not advisable to open and close the circuit to the coil, but it can be short-circuited. The control of the

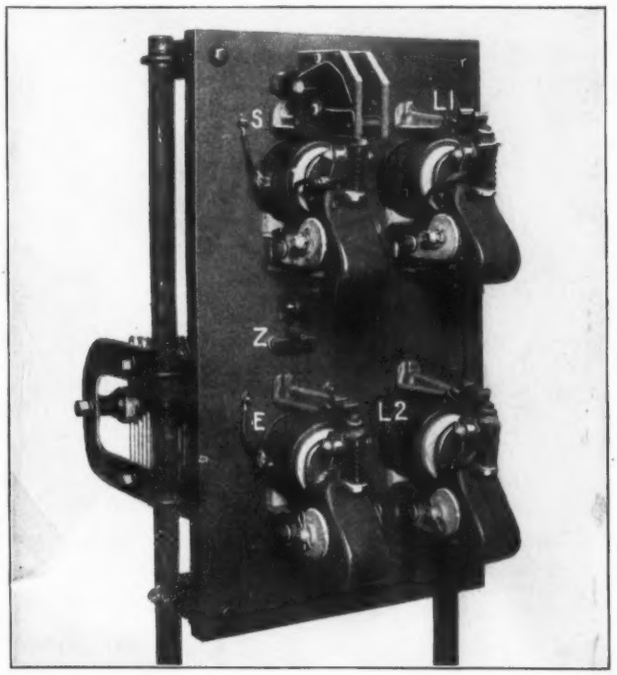


FIG. 2. CONTROLLER EQUIPPED WITH ONE COUNTER-E.M.F., ONE SHUNT AND TWO LOCKOUT CONTACTORS

coil circuit of a series contactor is accomplished by the switch itself, by virtue of its characteristics, therefore it is automatic and self-contained.

When this switch was first presented, it seemed almost "spooky" to those not very familiar with the magnetic circuit and its possibilities. Upon satisfactory demonstration it then looked like a panacea for all the ills of magnetic-switch control. Regardless of the fact that the designers were well aware of its limitations in application, attempts were and are yet made to apply it to service to which it is not suited. Thus the switch has been too frequently criticized for the lack of characteristics which it was supposed to possess but did not.

Considering some of the general features of application of this switch, with its characteristics in mind, its limitations at once become apparent. One of the requirements of many contactors it what is known as a line switch, or the switch that establishes and interrupts the main circuit. Here it will be seen that the lockout contactor cannot be used, since its operating coil must be connected in the main circuit. To effect closure of the switch the main circuit will have to be closed, which is the very thing that is desired to be avoided, other than by the switch or contactor itself. Furthermore, its characteristics are such that it will not immediately close any circuit in which a heavy rush of current occurs. After closing, its holding circuit can be interrupted only

*The material in this article was contributed by W. H. Patterson, of the Westinghouse Electric and Manufacturing Co.

by breaking the main circuit, the thing the switch is installed to do. Hence the only contactor that can be used for such purpose must have the characteristics of the shunt switch.

Consider a condition where the current in the line, and therefore in the coil of the lockout contactor, falls to a very low point—lower than will give ampere turns enough to produce a pull that will maintain a contactor in a closed position against its contact spring. The lockout switch will drop open, and its reclosure can be predicted. If the current again climbs slowly, it will close at what is known as its pull-in point, but if the current climbs rapidly, as is frequently the case, it will pass this point, locking out until the current slowly descends to the pull-in point. If the cycle of the current is repeated, the contactor will repeat, and this is likely to be the case in some applications. The result is that the armature resistance is repeatedly cut in and out of circuit and the speed of the motor varied accordingly. Or the contactor may drop out from the cause stated and, for lack of returning load, not close again, thus running the machinery at a low speed, resulting in burning out the resistance, which was not designed to operate continuously on the circuit or load.

To overcome the condition mentioned there must be a switch or contactor which has a coil the current of which is quite constant or at least so within desirable limits. This contactor should be used to cut out or short-circuit the last resistance step. Such a coil may be energized from the main-circuit voltage, connected across the line, or it may be energized by the voltage across the armature of the motor. In the former case it is in effect a shunt contactor; in the latter case it is known as a counter-e.m.f. switch. In the former case the switch will hold in until the voltage of the line falls to a given low point, and in the latter case until the counter-electromotive force of the motor falls to a given value. It will be noted that by this means the switch has become independent of the current in the main circuit of the motor, for holding in the last switch. The shunt switch will open, as stated, only on failure of voltage of the line, opening of its circuit, or on very low voltage.

Fig. 1 shows a controller that employs two lockout switches L_1 and L_2 and one counter-electromotive-force switch E to cut out the starting resistance. Fig. 3 is a wiring diagram of the controller shown in Fig. 1. It will be seen that this is a no-voltage release type of starter, in that contact E will drop out when the counter-electromotive force drops to a predetermined limit, but there is nothing to prevent a restart on the return of voltage, as long as the line knife switch is closed. This type of starter is suitable for use with a motor driving a pump, blower, etc., but would be dangerous where the operator might get hurt by the sudden starting up of the machine.

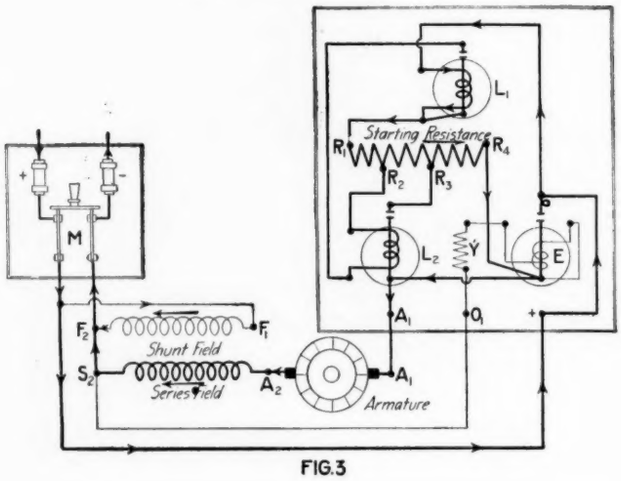


FIG. 3

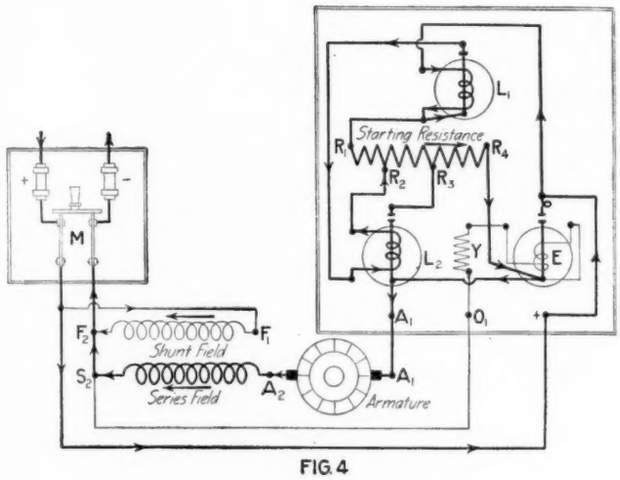


FIG. 4

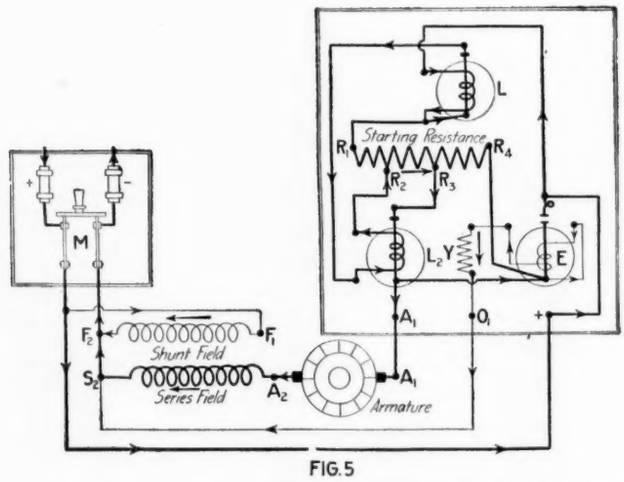


FIG. 5

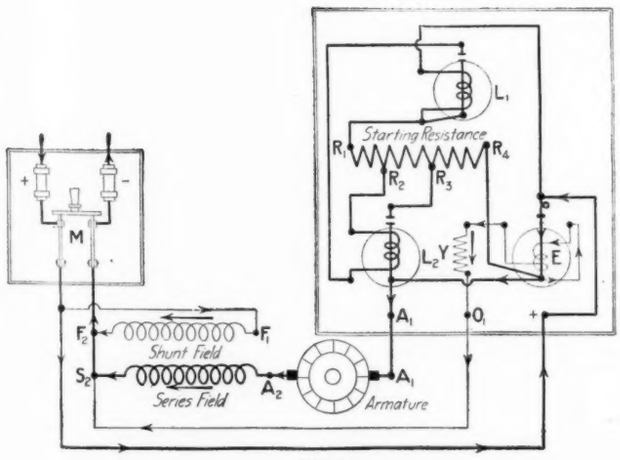


FIG. 6

FIGS. 3 TO 6. CONNECTION DIAGRAMS FOR THE CONTROLLER SHOWN IN FIG. 1

The operation of the controller shown in Fig. 1 is explained as follows: Referring to Fig. 3 and closing the line switch *M*, current can flow from the positive side of the line through the shunt field to the negative side of the line, as shown. The armature circuit is also from the positive side of the switch to the + terminal on the controller, around through the coil on contactor L_1, contactor, to A_1, and back through the motor, thus cutting out the section of resistance between points R_3 and R_4, which will cause a further increase in the speed of the motor. All the time the motor has been increasing in speed, also the pressure across its terminals, consequently the current through the coil on the counter-electromotive-force switch *E*. The circuit for the coil

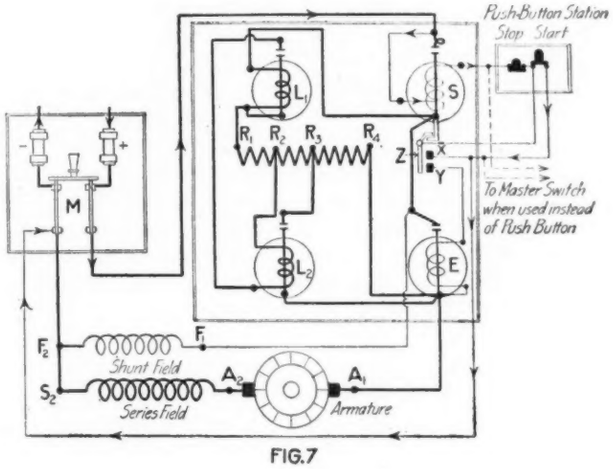


FIG. 7

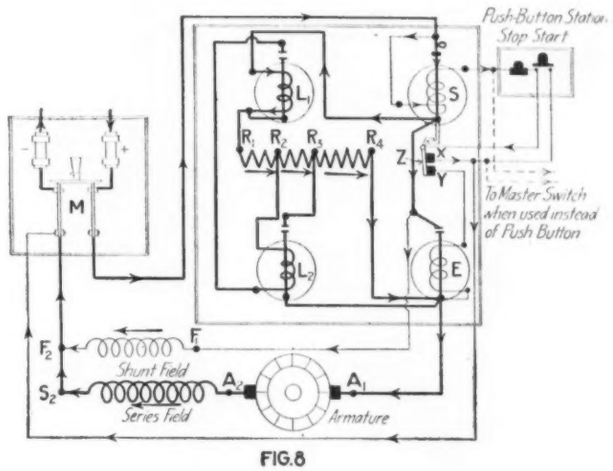


FIG. 8

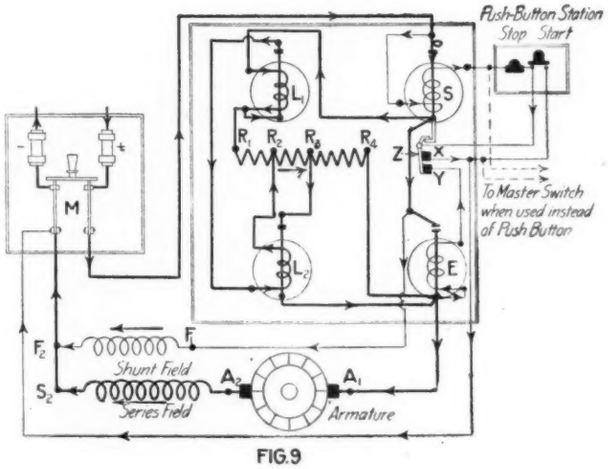


FIG. 9

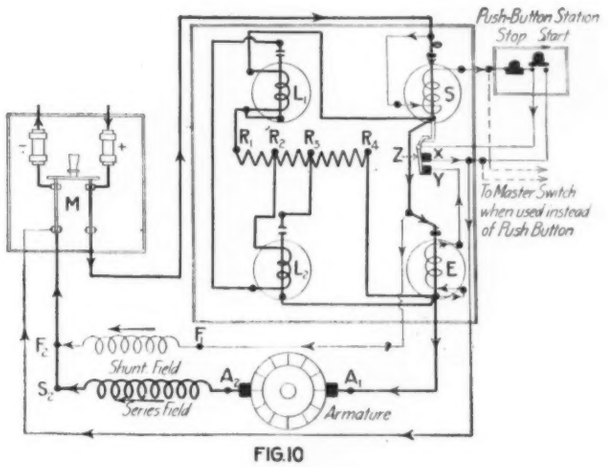


FIG. 10

FIGS. 7 TO 10. CONNECTION DIAGRAMS FOR THE CONTROLLER SHOWN IN FIG. 2

through all the starting resistance to A_1 on the controller, down to the armature and series-field winding of the motor to the negative side of the line, as indicated by the arrowheads. The inrush of current through the coil on contactor L_1 causes it to lock open until the motor has started and reached a predetermined speed, when the switch closes, as explained in the article in the issue of May 15.

Fig. 4 shows L_1 contactor closed. This provides a circuit for the current through contactor L_1, down through the coil of contactor L_2, up to R_2 on the starting resistance, to R_4, and back to the motor and the negative side of the line, as indicated. Cutting out the section R_1R_2 of the starting resistance causes another inrush of current to the motor, which prevents contactor L_2 from closing until the motor has again increased in speed and the current decreased to a value that will allow the switch to close. When switch L_2 closes, Fig. 5, the armature current takes a path through the coil of contactor L_2 to R_2 on the starting resistance, to R_3, and down through L_2 on this switch is from the bottom of contactor L_2 to the bottom of contactor *E*, through the coil and resistance *Y* to terminal O_1 on the controller and to the negative side of the line. The closing of contactor L_2 causes the motor to increase in speed to the point where the counter-e.m.f. becomes high enough to set up sufficient current in the coil of switch *E* to close it, as in Fig. 6, providing a direct path for the current from the positive terminal on the controller through contactor *E*, to the bottom of contactor L_2, to the motor and the negative side of the line. A circuit is also provided for the coil on switch *E*, to the negative side of the line, as shown by the arrowheads. Closure of the last switch cuts out the last section of the starting resistance, applies full voltage to the motor, and causes it to come up to full speed. The coils on contactors L_1 and L_2 are also short-circuited, therefore these contactors open, leaving only contactor *E* closed.

A controller is shown in Fig. 2 that is equipped with an automatic line switch *S* of the shunt type, which may

be controlled by a push-button, a float switch, or pressure regulator, etc. The starting resistance is cut out by the two lockout switches L_1 and L_2, and the counter-electromotive switch E. Upon closing the starting device the line switch S closes, the series lockout switches L_1 and L_2 closing in sequence as the motor comes up to speed; and the counter-electromotive switch E closes last, cutting out all the resistance and putting full voltage on the motor.

Fig. 7 is a wiring diagram of the controller shown in Fig. 2. Closing the starting button in Fig. 7, a circuit is created from the positive terminal of the switch M, through the coil on the shunt-line switch S, through the stop button, which is normally closed, and the starting button, which is normally open, around to the negative side of the line. Energizing the coil on switch S causes it to close its contactor, as shown in Fig. 8. The closing of switch S also closes the interlock Z connected to the bottom of this switch, also shown in Fig. 2, thus making contact between points X and Y; completing a holding circuit for the shunt coil through the stop button and the interlock Z, to contact X and the negative side of the line, as shown. Therefore the starting button may be released, which stands normally open, without affecting the function of the coil on switch S.

The Operation of the Controller

The closure of switch S provides a circuit for the motor from the positive side of the line to the bottom of contactor S. At this point the current divides, one circuit being down to the top of contactor E, through the shunt-field winding to the negative side of the line. The armature circuit is through the coil on contactor L_1; all the starting resistance to the bottom of contactor E, then through the armature and series-field winding to the negative side of the line, as shown by the arrowheads. Contactors L_1 and L_2 function, as explained, for L_1 and L_2 in Figs. 3, 4 and 5, cutting out starting-resistance sections R_1R_2 and R_3R_4 (see Fig. 9).

The circuit is from the bottom of contactor S, through the coil and contactor of switch L_1, through the coil on switch L_2, up to R_2 on the starting resistance, to R_3, through contactor L_2, to the bottom of contactor E, through the armature and to the negative side of the line. As the motor increases in speed, the pressure across the terminals of the coil on switch E increases, owing to the increased counter-electromotive force of the armature.

The circuit for the coil on contactor E is from the bottom terminal of the contactor, through the coil to contact Y on the interlock of switch S, through the interlock to the negative side of the line. With contactors L_1 and L_2 closed, the motor reaches a speed where the counter-electromotive force of the armature becomes high enough to cause contactor E to close, as indicated in Fig. 10. This provides a circuit for the motor direct from the positive side of the line, through contactors S and E to the motor, and short-circuits L_1 and L_2 out of circuit, causing them to open as shown. The coil of switch E is also connected directly across the line. The motor is now connected directly across the line, which causes it to run up to full speed.

It has been seen that the interlock Z, which is closed by switch S, makes the circuit for the counter-electromotive-force switch. On the occurrence of low voltage or failure of voltage, the shunt-line switch E will drop open, and in so doing will allow the interlock to open, cutting off the circuit to switch E. This having occurred, the motor stops, and it will not again start until the operator pushes the button marked "Start." Such a starter affords no-voltage protection, and this illustrates the meaning and proper use of the terms, "no-voltage release" and "no-voltage protection." The starter, with no-voltage protection, may be used on motors applied to machine tools, woodworking machinery and similar devices.

There are classes of work for which it is desirable and important to operate the motor at speeds below normal, either continuously or for a considerable length of time, and the operator may require several such speeds. This is spoken of as point or selective armature control. It is quite obvious that the characteristics of the lockout contactor will not admit of use in this case. Shunt contactors, fed through a master switch, will give selective control, and if supplemented with current-accelerating relays will give automatically governed speeds of acceleration of the motor and load up to any point at which the master switch may be set.

As an example of application at which point control is necessary might be mentioned rubber calenders and printing presses. Here it gives the slow, or threading-in, speeds.

There are extremely few machines to which the lockout switch can be applied entirely throughout the controller. It will be seen that a fairly constant condition of load is necessary in order to keep out of trouble; as, for example, the plunger pump.

There have been given here some of the simplest diagrams as illustrations, but it is evident that there are numerous other pieces of apparatus required in controllers, including overload relays, field-accelerating relays, transfer relays, meters, dynamic-braking switches, reversers, etc., depending upon the conditions encountered and the type of machinery to be driven.

Ammonia Lodged in Condenser

By V. O. Safranck

Recently, I took charge of a plant that has been noted for its mysterious disappearances of ammonia, and I have had considerable trouble keeping enough ammonia in the receiver, notwithstanding that the plant had been recently overhauled by an expert.

After charging 350 lb. more ammonia into the 1500-lb. receiver and not finding a trace of it, I began investigating and finally decided that it was in the condensers even though I could not pump it down from there. I put oily waste in the pan under the condenser coils and warmed them with a light blaze. The liquid soon filled the receiver.

But the next day the same thing happened again, so I decided that the fault was with the design of the condensers. I pumped down two coils out of five under a light temperature to facilitate the movement of the liquid from them. After thoroughly pumping down, I cut them out and then ran on three coils. Since then the receiver is almost full while running and the head pressure is lower. Before cutting out the two coils this pressure was from 120 lb. to 180 lb.; now it sometimes comes down to 105 lb. V. O. Safranck.

Continuous Service Switch

One of the factors determining the excellency of an electric service is continuity of supply. In many cases, such as public buildings of every kind, it is absolutely necessary to guarantee, as far as practicable, the continuity of the electric service. The laws of certain localities demand that these premises be supplied from two independent circuits. In most cases an attendant is depended upon to go to the main switchboard and throw a double-throw switch from the regular source to the emergency in case of failure of the former. Right here is the weakness of this scheme—the human element has to be depended upon. To eliminate this defect and make it possible to transfer from one source to another automatically, the "Hamilton Continuous Service Switch" has been designed by John Hamilton, West Roxbury, Mass.

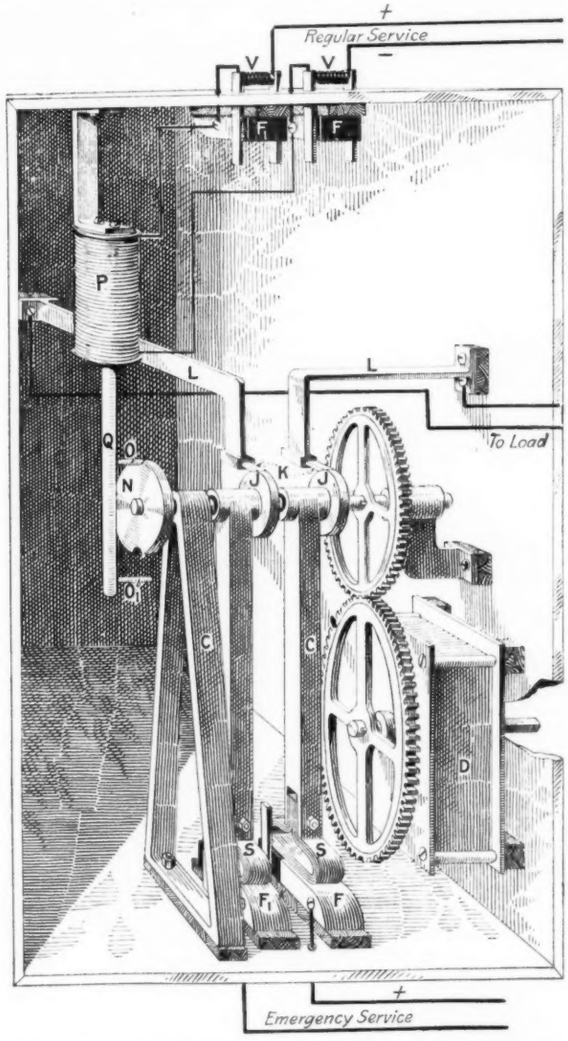


FIG. 1. DIAGRAM ILLUSTRATING PRINCIPLE OF SWITCH

Fig. 1 illustrates the principle and operating mechanism of a double-throw switch of the foregoing type. The switch blades, represented by C, are rigidly mounted on the shaft but insulated therefrom. D is a spring motor, which by means of the gears transfers the switch from one position to the other. The stationary contacts F and F_1 are made up of carbon and copper, through which the switch completes the circuit by the spring contact S. Arms L and L carry brushes, which rest upon the contact wheels J and complete the circuit from the source of power through the switch to the load. N is a limit wheel which controls the operation of the switch by the pins O and O_1 projecting from the solenoid core Q. By energizing or deënergizing the solenoid coil P, the core Q is drawn up or allowed to drop, thus controlling the position of the switch. Blowout coils V eliminate the arc when the switch opens the circuit.

As shown in the figure the switch is closed to the emergency position. The circuit is from the positive terminal to contact F through the left-hand switch member to the load and back through the right-hand switch member to the power source. When the regular service is restored, solenoid P is energized and core Q is drawn up. In doing so, pin O is raised out of the top notch in the limit wheel N, releasing the switch, which is made to revolve by the spring motor M. Before pin O_1 comes in contact with the limit wheel N, the bottom notch has moved out of position and the switch will not be stopped until it has revolved into the up position, when the solenoid will pull pin O_1 into what will then be the bottom notch of the limit wheel and hold the switch in this position. Should the regular service fail, the solenoid will be deënergized, allowing its core to drop, releasing the switch, which starts to revolve and turns to the emergency position, where it is stopped by the pin O dropping into the top notch in the limit wheel.

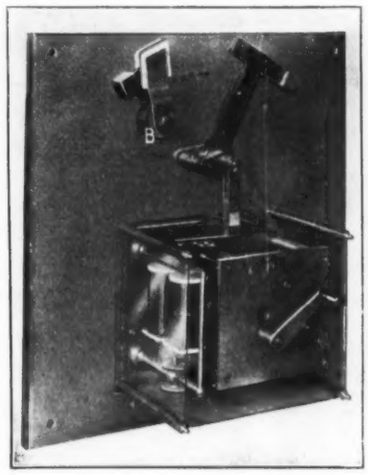


FIG. 2. SWITCH MODEL

Fig. 2 shows a model of this switch that has been designed and constructed to handle 75 amp. at 575 volts. By using a blowout coil B on the normal point of supply, the switch has successfully ruptured 175 amp. No blowout coil was used on the emergency-supply contact, the power on this side being alternating current against direct current on the regular-service side; the movement of the switch blade was quick enough to take care of the alternating arc. When used on a lighting circuit, the transfer was so rapid from normal to the emergency circuit, that the lamp could scarcely be observed to blink during the transition period.

Physical Strain As "Accident"—An employee engaged in firing a boiler in a steam-power plant sustained physical injury through strain in using a larger shovel than he was accustomed to in handling coal. He filed claim for an award under the New York Workmen's Compensation Act, and the employer objected that there was no such "accident," as justified an allowance. Holding against the employer's contention, the New York Industrial Commission said, speaking through Commissioner Lyon: "The use of this large shovel lifting coal of very much greater weight than he was accustomed to, followed by a strain which seems to have had the severe consequence testified to here, in my opinion, constitutes an accident, even though a strain in the ordinary course of his employment should not be held to be so, and I advise that the award heretofore made be confirmed." Malanzona vs. Utica Steam & Mohawk Valley Cotton Mills.

Combining Power, Heating and Ventilation--II*

By Ira N. Evans†

SYNOPSIS—Presentation of data showing a saving of 25 per cent. by properly correlating power and heating. Comparison is made between the usual blower system and a combination blower and forced hot-water system under various operating conditions, such as buying or making current and driving the fans by motors or engines. When generating power turbines are operated under the vacuum corresponding to the temperature of the water in the heating system.

The truth of the statements in the previous article, (see *Power,* May 22), is demonstrated by the following data and calculation arranged in the form of tables in such a way that the arithmetical calculations may be easily followed. Referring to Table VI, which summarizes the results, the column number at the side of each quantity and the table numbers at the top designate the derivation of the quantities. The resultant totals in heavy type are intended to be comparative rather than actual operating costs, as all are reduced to a minimum for comparative purposes. Any desired variation in costs or rates should be applied to all cases and the ultimate results will bear the same relations. The costs in heavy type, when deducted one from another and the difference capitalized at 25 per cent. per annum, will show the additional first cost that would be warranted for the more economical system.

Thus system 6, Table VI, gives the operating expense of heating, ventilation and power for the combination system, with 450 kw. average load, as $34,796 per annum and system 5 the cost of the blower system as $43,755 under the same conditions, a difference of $8959. The hot-water combination system would warrant an additional investment of $35,836 over the blower system, and the difference would be paid in four years. As a matter of fact the hot-water system complete, system 6, can be installed for the same or a less cost than the blower system 5.

There are various methods of operation[1] such as live steam with and without ventilation and power generation, but actually only two systems, one with blowers alone with steam distribution and the other with blowers and direct radiation with hot-water distribution.

Both systems including power generation are compared under headings 5, 6 and 7 of Table VI, the blower system being on a noncondensing basis and the hot-water system having condensing turbine equipment. The turbogenerators, being high-speed machines, are cheaper than reciprocating-engine units of the same class, but turbines are often not desirable unless operated condensing.

Systems 1 and 2, Table VI, show the cost of live-steam operation on the blower system with fan motors and purchased current in one case and fan engines with high-pressure steam distribution in the other. The interest and depreciation charges in Table VI are on items different or not common to all methods. In determining

TABLE I. DAY HEATING AND POWER COMBINATION SYSTEM

Col. I	Col. II	Col. III	Col. IV	Col. V	Col. VI	Col. VII	Col. VIII	Col. IX	Col. X	Col. XI	Col. XII	Col. XIII	Col. XIV	Col. XV
		23,000,000 ÷15× Col. IV				Col. III ÷ Col. VI		Col. VII ÷ Col. VIII	Col. IX — 230 Kw.	Col. X × Col. II	Col. VII × 1.2	Col. XII × Col. II	Col. VII × Col. II	(450 Kw. —Col. X) ×1.2 ×Col. VIII× Col. II
Outside Temp., Deg. F.	Hours Each Period	B.t.u. Loss per Hour	Temp. Drop on Water, Deg. F.	Vacuum In.	Latent Heat at Vac., B.t.u.	Heating Steam per Hour, Lb.	Steam Rate Turbine per Kw.-Hr., Lb.	Kw. Available from Heating Steam	Net Power Available from Heating Steam	Kw.-Hr. Available from Heating Steam	Steam per Hour f. and a. 212 Deg., Lb.	Steam per Period Heating and Power Lb.	Heating Only on Live Steam, f. and a. 212 Deg.	Additional Steam to Maintain 450-Kw. Load, Lb.
0–10	10	23,000,000	15	0	970	23,711	33	718	488	4,880	28,453	284,530	237,110	.....
10–20	50	19,933,000	13	6	977	20,402	30	680	450	22,500	24,482	1,224,100	1,020,100	.....
20–30	205	17,633,000	11.5	12	985	17,901	27	663	433	88,765	21,481	4,403,605	3,669,705	112,914
30–40	500	15,333,000	10	17	994	15,426	24	643	413	206,500	18,511	9,255,500	7,713,000	532,800
40–50	350	13,033,000	8.5	22	1,006	12,955	23	563	333	116,550	15,546	5,441,100	4,534,250	1,130,220
50–60	430	9,967,000	6.5	24	1,013	9,839	22.3	441	211	90,730	11,807	5,077,010	4,230,770	2,750,125
Total {	1,545*	.....	....	..	.....	.....	....	...	...	529,925	.....	25,685,845	21,404,935	.....
	1,455†	.....	....	28	.....	.....	20.5	...	...	.....	.....	Summer condensing....		16,106,850
														20,632,909
											5%	1,284,292	1,070,247	1,031,645
											Total Steam	26,970,139	22,475,182	21,664,554
											Coal.....	1,686 tons	1,405 tons	1,354 tons

* Heating season 10 hours a day. † Hours in summer turbines running.

TABLE II. NIGHT HEATING COMBINATION SYSTEM *

Col. I	Col. II	Col. III	Col. IV	Col. V	Col. VI	Col. VII	Col. VIII	Col. IX
		Table I— Col. III	4,323,870 / 60 Deg.	Col. IV × Col. VI	60 Deg. — Av. of Col. I	Col. III — Col. V	Col. VII ÷ 970 B.t.u.	Col. VIII × Col. II
Outside Temp., Deg. F.	Hours Each Period	B.t.u. Loss per Hour	B.t.u. Cor. per Deg. to Heat Loss When Fans Are Shut Down	B.t.u. Reduction When Fans Inoperative	Diff. in Temp. Room and Outside	Actual B.t.u. Loss per Hour	Steam per Hour f. and a. 212 Deg., Lb.	Total Steam per Period Lb.
0–10	66	23,000,000	72,064	.....	..	23,000,000	23,711	1,564,926
10–20	214	19,933,000	72,064	.....	..	19,933,000	20,549	4,397,486
20–30	624	17,633,000	72,064	2,522,240	35	15,110,760	15,578	9,720,672
30–40	971	15,333,000	72,064	1,801,600	25	13,531,400	13,950	13,545,450
40–50	781	13,033,000	72,064	1,080,960	15	11,952,040	12,322	9,623,482
								38,852,016
						5% loss.....		1,942,601
						Total steam.....		40,794,617
						Coal.....		2,550 tons

* Fans not operated above 20 deg. outside temperature.
Heating discontinued nights above 50 deg. outside temperature.

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†Engineer, Johnson, Larsen & Co., Engineers, Contractors, Detroit, Mich.

[1]See A, B, C and D and systems 1, 2, 3, 4, 5 and 6 in Table VI.

the relative costs and the best system to adopt in any particular case, the problem would have to be worked out individually, as these figures only indicate what is possible and wherein the savings are effected.

System 7 of the same table gives the results of increasing the power load from 450 to 700 kw. average, on the combination system. The blower system was not worked out for the larger load, inasmuch as it would mean excess steam from power over the heating requirements too large a proportion of the time on a noncondensing basis. Higher prices of fuel might make the 700-kw. load less favorable. The cost of purchasing 700-kw. average load at 1¼c. per kw.-hr. over 450 kw. (D, systems 3 and 4, Table VI) is $9375. The difference when generating the power is $11,483 (C and D, systems 6 and 7) or the saving is reduced by $2108 per annum by the increased power load.

It is interesting to notice the quantity of water lost to the atmosphere in systems 5, 6 and 7. It is 685,000 cu.ft. for 450-kw. average load on the noncondensing blower system as against 346,000 and 475,000 cu.ft. for the combination system with 400- and 700-kw. loads respectively. These quantities are obtained by dividing the surplus steam by 62.5, the weight of a cubic foot of water. This shows that with a cooling tower there is less water used for condensing purposes than if noncondensing conditions were established and steam exhausted to the atmosphere. Lack of cheap condensing water is no bar to condensing operation.

For a 450-kw. load, 3000 hours, there is a comparative operating expense of $61,013 (C, system 1) for the fan system purchasing current at 1¼c. per kw.-hr. as against $34,796 (C, system 6) for the hot-water system performing the same service. This is a difference of $26,217 per annum, or more than could possibly be made up by any question of difference in opinion of expense of operation or installation.

The data in Table VI show that whether current is purchased or generated, the hot-water combination system of blowers and direct radiation would prove the more economical. A study of the tables will show the reasons to be due to the ability to vary the water temperature or circulation to meet a wide range of heating requirements and to operate the power load at all times under vacuum. The reduction in the quantity of air handled and the necessary hours of fan operation on the combination system over the blower system is favorable both for purchased current and power generation. Each of the foregoing operations would induce economy individually, but their combination in one heating, ventilating and power-generating system enables the maximum of economy to be obtained.

The several tables will be discussed briefly, directing the reader's attention to various columns to show how these results are obtained. In Table I the operating conditions are as follows: 300,000 cu.ft. of air per minute and 40,000 sq.ft. of direct radiation are provided to supply the maximum heat loss, 23,000,000 B.t.u. per hour, in the 0- to 10-deg. period. The hourly losses for the periods of higher temperature were calculated from observations of the drop in water temperature in a similar plant where the quantity of water circulated was constant. Thus the minimum heat loss is 9,967,000 B.t.u. with a 6.5 deg. drop in the 50-60-deg. period, this result being obtained by multiplying the maximum B.t.u. loss, 23,000,000, by the ratio of the temperature drops; namely, 6.5 ÷ 15. These data were observed in a plant supplied with a venturi meter and in which the temperatures, vacuum and load were observed every four hours for an entire winter.

TABLE III. BLOWER SYSTEM, FANS DRIVEN BY ENGINE OR BY MOTOR*

Col. I	Col. II	Col. III	Col. IV	Col. V	Col. VI 44,280,000 × Col. V	Col. VII Col. VI ÷ 1,000	Col. VIII	Col. IX Max from Col. VII or Col. VIII	Col. X Col. IX × Col. IV	Col. XI Col. VII × Col. IV	Col. XII Col. III × Col. VII
Outside Temp., Deg. F.	Hours Day Periods	Hours Night Periods	Total Hours	Heat Loss Factor	B.t.u. Loss per Hour	Steam per Hour Heating Only, Lb.	10x40x40 Lb. 10x25x50 Lb. Steam for Fan Eng. Lb.	Steam per Hour, Lb.	Steam per Period Fan Eng. Ex. and Live Steam	Live Steam at 80 Lb. Fans Dr. by Motor	Steam for Night and Sunday Heating
0–10	10	66	76	1.0	44,280,000	44,280	16,000	44,280	3,365,280	3,365,280	2,922,480
10–20	50	214	264	0.75	33,210,000	33,210	16,000	33,210	8,767,440	8,767,440	7,106,940
20–30	205	624	829	0.55	24,354,000	24,354	16,000	24,354	20,189,466	20,189,466	15,196,896
30–40	500	971	1,471	0.35	15,498,000	15,498	16,000	16,000	23,536,000	22,797,558	15,048,558
40–50	350	...	350	0.2	8,856,000	8,856	12,500	12,500	4,375,000	3,099,600	.....
50–60	430	...	430	0.15	6,642,000	6,642	12,500	12,500	5,375,000	2,856,960	.....
									65,608,186	61,075,404	40,274,874
								5%.....	3,280,409	3,053,770	2,013,744
									68,888,595	64,129,174	42,288,618
								Coal.....	4,306 tons	4,008 tons	2,643 tons

* All air recirculated—65 deg. temperature—600,000 cu.ft. per min.
Above 40 deg. fans slowed down. Steam at 80 lb. pressure, 40 lb. per hp., 400 hp.

TABLE IV. BLOWER SYSTEM, HEATING AND POWER, NONCONDENSING ENGINES*

Col. I	Col. II	Col. III Table III Col. VII	Col. IV Col. III ÷ 33	Col. V Table III Col. VIII	Col. VI Col. IV — Col. V	Col. VII Col. VI × Col. II	Col. VIII Col. III × 1.107	Col. IX 450 Kw. Col. VI	Col. X Col. IX × 33×1.107	Col. XI Col. X × Col. II	Col. XII Col. VIII + Col. X × Col. II
Outside Temp., Deg. F.	Hours Each Period	Steam per Hour for Heating, Lb.	Kw.-Hr. Available from Heating Steam	Power for Fans, Kw.	Net Kw. Recovered From Heat Steam	Power Recovered from Heat Steam, Kw.-Hr.	Steam per Hour, f. and a. 212 Deg., Lb.	Kw. Required in Addition to that from Heating	Steam f. and a. 212 Deg. for Add. Power, Lb.	Steam to Atm. and Add. for 450 Kw. Over Heating, Lb.	Steam per Annum, Power and Heating, f. and a. 212 Deg., Lb.
0–10	10	44,280	1,342	300	1,042	10,420	49,018	...	.....	.....	490,180
10–20	50	33,210	1,006	300	706	35,300	36,763	...	.....	.....	1,838,150
20–30	205	24,354	738	300	438	89,790	26,960	12	438	89,790	5,616,590
30–40	500	15,498	470	300	170	85,000	17,156	280	10,228	5,114,000	13,692,000
40–50	350	8,856	268	190	78	27,300	9,803	372	13,589	4,756,150	8,187,200
50–60	430	6,642	201	190	11	4,730	7,353	439	16,037	6,895,910	10,057,700
Summer	1,455	....	.....	....	...	.....	.....	450	16,438	23,917,290	23,917,290
						252,540				40,773,140	63,799,110
									5%.....	2,038,657	3,189,955
										42,811,797	66,989,065
									Coal.....	2,676 tons	4,187 tons

* Power load 450 kw. net. To operate fans 300 kw.
Steam at 150 lb. pressure, 100 deg. superheat.

In Table I the initial steam pressure for the combination system is assumed to be 150 lb. gage and 150 deg. of superheat. With an average feed-water temperature of 150 deg., the evaporation factor is 1.2.

If motor driven, the fans, in conjunction with the hot water circulating pump, are estimated to require 230 kw., which in Col. X is deducted from the available power given in Col. IX, Table I. If the fans were operated on a mechanical efficiency of 90 per cent., a generator efficiency of 90 per cent. and a line loss of 5 per cent., this rate reduces to 33 lb. per kw.-hr. at the point of service.

It is interesting to notice that the power available from the heating steam reduces more slowly than the quantity of steam, owing to the decreasing water rate of the turbine as the vacuum is increased in moderate weather (see Cols. VII and IX, Table I). In the plant

TABLE V. COST OF VENTILTION, BOTH SYSTEMS

Col. I	Col. II	Col. III	Col. IV	Col. V	Col. VI	Col. VII	Col. VIII	Col. IX	Col. X	Col. XI	Col. XII	Col. XIII	Col. XIV	Col. XV	Col. XVI	Col. XVII	Col. XVIII	Col. XIX	Col. XX
Outside Temp., Deg. F.	Hours Each Period	Rise in Temp., Outside Air, Deg. F.	Table IV, Col. VI, Net Kw. from Heat. Steam	1,000 Cu.Ft. Outdoor Air per Min.	Col. V × Col. III × 1.268, Steam for Heat. Outdoor Air, Lb.	Col. VI + 33, Net Kw. Available from Vent. Steam	Col. IV + Col. VII, Total Kw. from Heat. and Vent.	Table I, Col. VIII, Steam Rate per Kw.	Table I, Col. X, Net Kw. from Heating Steam	1,000 Cu.Ft. Outdoor Air per Min.	Col. III × Col. XI × 1.268, Steam for Heat. Outdoor Air	Col. XII ÷ Col. IX, Kw. Recovered from Vent. Steam	Col. XIII + Col. X, Total Net Kw. Available Heat. and Vent.	Col. XII × 1.2, Steam for Vent. and Power, f. and a., 212 Deg.	Table I, Col. XII + Col. XV, Steam per Hr., Heat., Vent. & 700 Kw.	Col. XV × Col. II, Steam per Period Vent. and 700 Kw.	1,000 Cu.Ft. Outdoor Air per Min.	Col. III × Col. XVIII × 1.268, Steam for Heat Outdoor Air, Lb.	Col. XIX × Col. II, Steam per Period for Outdoor Air, Lb.
0–10	10	60	1,042	...	.....	...	1,042	33	488	95	7,228	219	707	8,674	37,127	86,740	200	15,216	152,160
10–20	50	50	706	...	.....	...	706	30	450	120	7,608	254	704	9,130	33,612	456,500	200	12,680	634,000
20–30	205	40	438	75	3,804	115	553	27	433	140	7,101	263	696	8,521	30,002	1,746,805	200	10,144	2,079,520
30–40	500	30	170	300	11,412	346	516	24	413	185	7,037	293	706	8,444	26,955	4,222,000	200	7,608	3,804,000
40–50	350	20	78	300	7,608	230	308	23	333	200	5,072	221	702	6,086	25,362	3,435,600	200	5,072	1,775,200
								21	Full vac.		3,108	148		3,730					
50–60	430	10	11	300	3,804	115	126	22.3	211	200	2,536	113	700	3,043	18,301	2,792,420	200	2,536	1,090,480
								21	Full vac.		2,876	376		3,451					
Summer condensing 1,455 hours								20.5	Full vac.		14,350		700	17,220	17,220	25,055,100			
																37,795,165			9,535,360
														5%		1,889,758			476,768
																39,684,923			10,012,128
														Coal		2,480 tons			626 tons

purchased current, the power for the circulating pump only would be deducted, as it would be steam-driven in any case, utilizing the exhaust for heating. For the fans 150 kw. would be required:

$$1545\ hours \times 150\ kw. \times 1\tfrac{1}{4}c. = \$2897$$

and in Table II, the first two periods for night heating, or

$$280\ hours \times 150\ kw. \times 1\tfrac{1}{4}c. = \$525$$

a total of $3422 per annum for fan operation on the combination system.

from which these data were obtained, the exhaust steam from a 450-kw. load exactly balanced the heating requirements from fall until spring by simply varying the vacuum between atmosphere and 28 inches.

In average winter weather vacuums of over 20 in. make the steam rate per kilowatt only slightly more than under full vacuum. Power is usually required during the day periods only, when the temperatures are higher than at night. There are many days even in January and February when the temperature is 40 to 50 deg., so that with

TABLE VI. SUMMARY OF RESULTS ON ALL ARRANG

Items of Cost of Installation and Operation	Estimated Cost per Unit	Rate per Annum, Int. and Dep. per Cent.	Charge per Unit per Annum	Live Steam-Operation—Blower System: 1 Public-Service Current for Fans, Steam 80-Lb. Gage Table III			Live Steam-Operation—Blower System: 2 Fan Engines High-Pressure Steam Distribution Table III			Power Purchased—Combina: 3 Public-Service Current for Fans Hot Water Tables I–II		
				Col.	Amount	Charge	Col.	Amount	Charge	Col.	Amount	Charge
Max. boiler power zero period—34.5 lb. per hp	.....	..	...	IX	1,284 hp.	.....	IX	1,284 hp.	.....	VII	690 hp.	.....
Boilers per hp	$35	20	$7	.....	1,300 hp.	$9,100	.....	1,300 hp.	$9,100	....	700 hp.	$4,900
Turbines—Engines per kw	25	16	4	.....	.....	.....	.....	.....	.....	....	.....	.....
Condensers per kw	10	10	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hot-water heaters, pumps	.....	10	...	.....	.....	.....	.....	.....	.....	....	$3,000	300
Fanhouses, each	2,000	8	160	.....	10 houses	1,600	.....	10 houses	1,600	....	4 houses	640
Coal night heating	.....	..	...	XII	2,643 tons	.....	XII	2,643 tons	.....	IX	2,550 tons	.....
Coal day heating	.....	..	...	XI-XII	1,365 tons	.....	X-XII	1,663 tons	.....	XIV	1,405 tons	.....
Coal excess steam for power and vent	.....	..	...	.....	.....	.....	.....	.....	.....	....	.....	.....
Total fuel	$4 per ton			XI	4,008 tons	$16,032	X	4,306 tons	$17,224	....	3,955 tons	$15,820
Surplus steam to atm	$1 per 1,000 cu.ft.			.....	.....	.....	.....	.....	.....	....	.....	.....
Current purchased, kw.-hr	1¼c. per kw.-hr.			.....	940,200	11,752	.....	.....	.....	....	273,750 kw.	3,422
A Operating cost, heating only (I)						$38,484			$27,924			$25,082
B Operating cost, heating and ventilation (I+8) (2+8) (3+8) (4+8)					Ventilation 1,750 b.hp.	$5,654 $44,138		Ventilation 1,750 b.hp.	$5,654 $33,578		Ventilation 1,150 hp.	$5,654 $30,736
C Operating cost when buying current for power 450 kw. × 3,000 hr. = 1,350,000 kw.-hr. @ 1¼c					1,350,000 kw.-hr.	$16,875 $61,013		1,350,000 kw.-hr.	$16,875 $50,453		1,350,000 kw.-hr.	$16,875 $47,611
D Operating cost when buying 700 kw. 3,000 hr. 2,100,000—1,350,000 = 750,000 kw.-hr. @ 1¼c					750,000 kw.-hr.	$9,375 $70,388		750,000 kw.-hr.	$9,375 $59,828		750,000 kw.-hr.	$9,375 $56,986

The steam rates, Col. VIII of Table I, were those of a 500-kw. turbine, operating on steam at 150 lb. and 150 deg. superheat. These rates could be bettered in practice. The engine rate assumed for the noncondensing blower system, Table IV was 19 lb. per i.hp.-hr. with steam at 150 lb. pressure and superheated 100 deg. Assuming the combination system a vacuum of 20 to 24 in. could be carried.

Low vacuums are required only a few hours in the season. According to Cols. II and V, Table I, there are only 265 hours when the vacuum is 12 in. or below. In zero weather the apparatus operates at 212 deg. and the

high steam rate of the turbine noncondensing is here desirable to balance the heating.

With the noncondensing equipment and vacuum steam heating, the buildings become overheated and a large amount of exhaust passes to the atmosphere. The actual kilowatt rate might even be greater in moderate weather than for the colder periods in winter.

Tables III and IV give the data for the blower system. The heat losses, Col. VI, Table III, are based on 600,000 cu.ft. of air per minute, recommended by the manufacturer. The figures seem high, but the air was calculated to be raised 60 deg. above the room temperature, or to 120 to 125 deg. leaving the fan heater. As there are only a few hours of extreme weather operation, this does not affect the total results materially except for the boiler horsepower necessary to carry the peak load. Col. V was derived from the Sturtevant book "Heating and Ventilation," in which is given a chart with curves showing percentages of heat required for various outdoor temperatures when the maximum loss in zero weather is known. In the present case the heat required to raise 600,000 cu.ft. of air per minute to 120 deg. final temperature would be

$$600{,}000 \times 1.23 \times 60\ min. = 44{,}280{,}000\ B.t.u.$$

Power for the fans was assumed as 400 hp., requiring at 40 lb. per hp. 16,000 lb. of steam per hour. Above 40 deg. outside temperature the air supply is reduced by slowing the fans so that they take but 250 hp. and at 50 lb. per hp. in this case require 12,500 lb. of steam per hour, as shown in Col. VIII, Table III.

Steam is distributed at 80 lb. pressure and the exhaust utilized at each fan unit. With a feed temperature of 200 deg. or perhaps less, the latent heat in the steam would approximate 1000 B.t.u. per lb. No power would be available from this system, but the distributing mains would be small and the lowest in first cost to install. Night and day periods are given in Table III, but the apparatus is discontinued above 40 deg. at night. See Col. III, Table III.

When the fans are operated by public-service current the total kilowatt-hours required is obtained by multiplying the total hours in Col. IV, Table III, by the kilowatts in Col. V, Table IV. The product in this case is 940,200 kw.-hr., which at 1¼c. amounts to $11,752, or $8330 more to operate the fans in the blower system than in the combination system.

In Table IV power is generated with steam at 150 lb. pressure and 100 deg. superheat. The exhaust from the main engines is utilized, and the fans are operated by motors. With 210-deg. feed water the evaporation factor is 1.107, as indicated in Col. VIII. The power load on the noncondensing engines is 450 kw. net, with 300 kw. to operate the fans.

Table V shows the effect of using one-third outdoor air on the blower system, Col. XVIII to XX, and the cost of raising the average power load from 450 to 700 kw. on the combination system, Col. XI to XIV. It also shows that the blower system would not pay if the power load was increased to 700 kw. The factor 1.268 used in Col. VI and XII is the amount of steam required to raise 1 deg. 1000 cu.ft. of air.

In all cases 5 per cent. is added to the total steam. An evaporation of 8 lb. from and at 212 deg. per lb. of coal is assumed. There are 2000 lb. of coal to the ton, and boiler horsepower is determined by dividing the steam from and at 212 deg. by 34.5. All current is purchased at 1¼c. per kw.-hr.

Table II summarizes the night heating on the combination system. Live steam is utilized as there is no power. The heating is discontinued at 50 deg. outside temperature instead of 40 deg., as in the case of the blower system, which is entirely favorable to the latter. The fans are operated only at periods below 20 deg. outside temperature, the direct radiation taking care of the heating by higher water temperatures. In Col. IV, Table II, the heat loss due to the air change is reduced by one-half for night heating when the fans are inoperative. This correction is divided by 60 and multiplied by the differences in temperature given in Col. VI. In case there are night shifts the periods in Table I would apply, increasing the economical showing due to the longer periods of operation.

In Table IV it is of interest to observe the wide range in requirements for the blower system. In Col. VIII the steam requirements in the 0- to 10-deg. period are 49,018 lb. per hour as compared to 7353 lb. in the 50-

EMENTS OF BLOWER AND COMBINATION SYSTEMS

tion System— 4 Power-House Current for Fans Hot Water Tables I–II			Heating—Power—Ventilation — Blower System— 5 150 Lb., 100 Deg. Suph.-L.P. St. Heating-450-Kw. Av. Power Load Table III–IV			Combination System— 6 450 Kw. Av. Load Tables I–II			7 700 Kw. Av. Load Tables I–II–V			Ventilation — Systems 1, 2, 3, 4— 8 Cost of 200,000 Cu.Ft. Air per Min. 0–60 Deg. Table V		
Col.	Amount	Charge	Col.	Amount	Charge	Col.	Amount	Charge	Col.	Amount	Charge	Col.	Amount	Charge
VII	690 hp.	.....	VIII	1,420 hp.	.....	XII	825 hp.	.....	XVI	1,076 hp.	.....	XIX	441 hp.	.....
.....	700 hp.	$4,900	.....	1,450 hp.	$10,150	.....	850 hp.	$5,950	.....	1,100 hp.	$7,700	.....	450 hp.	$3,150
.....	500 kw.	2,000	.....	1,000 kw.	4,000	.....	1,000 kw.	4,000	.....	2,000 kw.	8,000	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	1,000 kw.	1,000	.....	2,000 kw.	2,000	.....	.....	.....
.....	$4,000	400	.....	.....	.....	.....	$5,000	500	.....	$6,000	600	.....	.....	.....
.....	4 houses	640	.....	10 houses	1,600	.....	4 houses	640	.....	4 houses	640	.....	.....	.....
IX	2,550 tons	.....	XII	2,643 tons	.....	IX	2,550 tons	.....	IX	2,550 tons	.....	.....	.....	.....
.....	1,405 tons	.....	XII–XI	1,511 tons	.....	XIII	1,686 tons	.....	XIII	1,686 tons	.....	.....	.....	.....
.....	.....	.....	XI	2,676 tons	.....	XV	1,354 tons	.....	XVII	2,480 tons	.....	XX	626 tons	2,504
.....	3,955 tons	$15,820	.....	6,830 tons	$27,320	.....	5,590 tons	22,360	.....	6,716 tons	26,864	.....	.....	$5,654
.....	.....	.....	XI	685,000 cu.ft.	685	XV	346,000 cu.ft.	346	XVII–XX	475,000 cu.ft.	475	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
		$23,762				.....	.....	.....	.....	.....	.....	.....	.....	.....
	Ventilation	$5,654				.....	.....	.....	.....	.....	.....	.....	.....	.....
	1,150 b.hp.	$29,416				.....	.....	.....	.....	.....	.....	.....	.....	.....
	1,350,000 kw.-hr.	$16,875				.....	.....	$34,796	.....	.....	.....	.....	.....	.....
		$46,391			$43,755	.....	.....	.....	.....	.....	.....	.....	.....	.....
	750,000 kw.-hr.	$9,375				.....	.....	.....	.....	.....	.....	.....	.....	.....
		$55,666				.....	.....	.....	.....	.....	$46,279	.....	.....	.....

to 60-deg. period. In Col. VI the variation in available power is from 1042 kw. to nothing. For the combination system reference to Cols. VII and IX, Table I, will show that the steam requirements vary from 23,711 lb. to 9839 lb. per hour and the available kilowatts from 718 to 441 respectively. Deducting 230 kw. for the fans and pumps leaves available 488 kw. in zero weather and 211 kw. in the 50- to 60-deg. period. During the latter period the water rate of the turbine per kilowatt is 22.3 lb., as compared to 20.5 lb. at full vacuum. The difference of 1.8 lb. per kw. is the cost of exhaust-steam heating for this period. With the advantage of the 211 kw. condensing capacity of the heating system, the cost of heating in moderate weather is practically nothing.

Comparison of Systems

In Table I, Col. XI, it will be noticed that from the steam for day heating by the combination system there are available 529,925 kw.-hr., as compared to 252,540 kw.-hr., Col. VII, Table IV, for the blower system, the latter figure being 47 per cent. of the former. On the blower systems the hourly load varies from 1042 to 11 kw. and on the combination system from 488 to 211 kw.

The type of heating load on the blower system is entirely unsuited for power owing to the wide variation and is one of the basic arguments of the central-station man why current should be purchased. In the combination system the conditions are entirely different, as the decreasing steam rate on the turbine for higher vacuums now nearly balances the heating requirements. It would be possible to discontinue the fans during the day or at such periods as the building is occupied when the weather is 30 deg. and above outside, but where power is generated, the additional vacuum due to lower water temperatures for heating makes it advisable to operate both fans and direct radiation at such times. When heating apparatus is operated in connection with condensing turbines, the condenser has to be operated to keep the fluctuation in the power load from increasing the water temperature. Any reduction in vacuum increases the steam rate rapidly (see Col. VIII, Table I), and the relief valve will open if the temperature of the circulated water is not controlled independently of the heating system.

Vacuum Controlled To Suit Temperature

With reciprocating engines it is not so easy to control the vacuum. A large compound engine will not operate satisfactorily over wide ranges in vacuum without adjusting the cutoff and compression. Carrying the load with a reduction in vacuum is much more difficult to provide for in a compound engine than in a turbine, for in the latter extra nozzles are readily available to help carry the power load. There are few engine plants operated in this manner, as below 10 in. of vacuum practically non-condensing results are obtained. Because of the lack of range in steam consumption between 0 and 26 in. of vacuum, the heating system will require more steam in extreme weather than the engine will furnish, and live steam has to be turned into the system at such times. Designing the plant for low water temperatures to meet this difficulty, say 150 deg. in zero weather, reduces the flexibility to meet outside weather conditions and makes the heating system bulky, cumbersome and expensive.

In the comparison no charge for extra labor on any system has been made, as this item would be about the same. When power is generated in the plant, the labor would be less than tending to ten fanhouses on the blower system when there would be all the apparatus of a complete engine room at each fan unit, with oil separators, lubrication, steam regulators, vacuum valves and traps. With the hot-water system all steam circuits may be sealed, doing away with all drain traps, drips, etc., which are a continual source of waste and attention in any steam plant. There might be additional labor for the system using steam-driven fans over that with motors and current purchased, but there is a sufficient margin to pay several good salaries in the difference in operating expense. It has been the author's experience generally that about the same number of men are employed in plants purchasing current as in those making it, especially during the heating season.

Cols. VII and VIII, Table III, give the heating demand and the steam for fan-engine operation. Even with the air supply curtailed so that the fans require 25 instead of 40 hp. per unit, there is double the steam from the fan engines in the 50- to 60-deg. period than is actually required for heating. This is what occurs on many fan systems, and the use of outdoor air utilizes the exhaust steam.

Pipe Radiator Objectionable in Mild Weather

The radiation of the large mains designed for 44,280 lb. per hr. of steam in zero weather on low-pressure distribution would be wasteful in higher-temperature periods, as the radiation loss would be about 10 per cent. of the maximum demand at all times, due to the constant temperature and pressure, even with the best insulation. As all mains of the combination system are within the building and independent of grades, they may be used as direct heating surface. Inasmuch as the temperatures are changed with that of the radiation proper, insulation is unnecessary, as it would mean additional radiation or higher water temperatures.

Although the fan system has a high peak load, the total steam per season and consequently the amount of coal required is not much different from that in the combination system. Col. XI, Table III, gives 4008 tons for the blower system and Cols. XIV and IX in Tables I and II give 2550 + 1405 = 3955 tons. These figures check fairly well considering they were arrived at by entirely different methods.

Table V gives the coal (Col. XX) necessary to heat 200,000 cu.ft. of outdoor air as 626 tons. The same amount would be required by any system using this amount of air for ventilation. This table also gives the cubic feet of outdoor air necessary to raise the condensing capacity of the hot-water system from 450 to 700 kw. See Cols. XI and XIV. Notice in Col. XVI the total variation in steam for heating, power and ventilation from 37,127 lb. in zero weather to 18,301 lb. per hour in the 50- to 60-deg. period. In Cols. IX, XII, XIII and XV, when the heating and ventilation will not balance the power load, the remainder is carried at full vacuum. Only one condenser is necessary, although with a 700-kw. load in summer two would be required. The 450-kw. load was assumed for both systems, as that seemed to balance the heating for the greatest part of the season. Col. XV, Table I, gives the additional steam over

heating required to maintain the 450-kw. load and indicates the work of the condenser and cooling tower for 3000 hours. There are 21,664,554 lb. of steam and 1354 tons of coal. In Col. XI, Table IV, 2676 tons of coal are required to generate the additional power over that required to balance the heating. Thus 2676 — 1354 = 1322 tons more coal is required by the blower system to maintain the electrical load. This is undoubtedly due to the noncondensing conditions, but with steam distribution there is no other way.

In periods above 30 to 40 deg. only one-half the air is taken from out of doors. This was because the horsepower and air supply was reduced (see Table III, Col. VIII) to save power in fan operation. If more air were taken from out of doors, the power to operate the fans would increase the steam consumption faster than the cooling effect of the additional air at higher temperature would condense it, so that there would be relatively less condensing power in the system.

Referring again to Table I, Col. XIV gives 1405 tons as the fuel for day heating by the combination system. According to Col. XIII the fuel for heating and power days is 1686 tons, and this added to the 1354 tons of Col. XV for additional steam gives a total of 3040 tons for heating and 450 kw. for 3000 hr. The total fuel for 450 kw., 3000 hours, and heating on the blower system, Col. XII, Table IV, is 4187 tons, or a difference of 4187 — 3040 = 1147 tons in favor of the combination system. Approximately, this is the 25 per cent. inherent saving generally acknowledged for hot-water systems over steam and for condensing conditions over noncondensing in power generation. The 5 per cent. added to all steam totals for losses is not sufficient to cover all losses of mains, fuel for banking fires and many other items common to boiler operation. If they were added, it would only increase the percentage in favor of the hot-water combination system.

In Table V, Col. XI, is given the quantity of outdoor air to increase the condensing capacity of the hot-water system from 450 to 700 kw. The additional fuel over the heating, as per Col. XVII, is 2480 tons. The quantities in Col. VIII show that the capacity of the blower system as a condenser cannot be raised beyond 450 kw. average with any economy, as it would mean more steam on a noncondensing basis to pass to the atmosphere.

The economies here presented are basic, and the operation and systems of heating compared were intended to be the best of their respective kinds in installation and design. The savings in the form of percentages can be realized on the combination system, as it can be arranged to dissipate the heat from the engines in large or small amounts at always a low final temperature, and the vacuum and quantity of heat delivered can be positively regulated with no trouble.

In general practice the most economical power-plant arrangement is not modified for the heating system. In fact, it is usual to adapt the heating system to the engine plant. It must be remembered, however, that a heating apparatus is a mighty poor condenser from a power standpoint and a condenser is a worse heating system from a heating standpoint. When owners and engineers will view the heating and power as adjunctive and to be correlated properly, these power-plant economies can be realized.

Operating Mechanical Stokers—III

By Warren O. Rogers

SYNOPSIS—The method employed in operating another type of retort underfeed stoker is described. One of the main points in its operation is to see that all adjustments are properly made, after which the automatic operation of the stoker will produce a proper state of combustion.

The principle of combustion is that when coal is fed into an ordinary furnace, gas is liberated by the heat and flows away above the mass, but burning only on the outside. This is incomplete combustion, and combustion cannot be complete until all the gas has burned away. All this must take place within a fraction of a second. Much attention has been given to the air supply to stokers so that the volume going to the furnace will be distributed to the fuel bed and that all the fuel will be properly consumed. To accomplish this the Type E stoker (Combustion Engineering Corporation) uses a central wind-box and a ventilated grate.

In the Type E underfeed stoker the coal is fed into a hopper on the outside of the furnace. From this hopper, Fig. 1, the fuel is delivered by gravity to the front end of the bottom of the retort and is then pushed into the furnace by a steam-driven feeder block until the retort, which runs the length of the furnace, is filled.

As the coal rises in the retort, it is flooded on the fire-bars, Fig. 2, by the movement of auxiliary pushers. The grate-bars are arranged alternately moving and fixed and reciprocate with the movement of the pusher, spreading the coked fuel toward the side or dump plates. The movement of the fire-bars also conveys the clinker and ashes to the dump trays. Consequently there is no need to clean the grate bars, as they are self-cleaning. Fig. 3 is a section through the center of a retort.

The bars are slightly inclined, but not enough to cause a gravity travel of the coal. The fire is kept clean by the mechanical movements of the bars, obtained by means of two helices and nuts placed outside the furnace, Fig. 1. These cause the moving bars to rock to and fro.

No hand adjustment of the stoker is necessary, after the furnace has been properly adjusted, as the automatics will take care of the load, be it heavy, light or fluctuating. Each stoker has an individual drive and is independent of any other stoker on the line, but by means of automatic control all are run at a uniform speed. A stoker may be cut in or out of service by throttling the driving engine and shutting off the air. A stoker may also be held with banked fire while the load is light, ready to cut in when desired. By feeding additional coal occasionally to replenish the bank, the fire may be kept in a banked condition several days. To start up again from a banked fire, dump the ashes, open the air gate and then start the stoker.

It is almost impossible to make some firemen realize that there is no need to slice or poke the fire. It is

unnecessary to break the caked fuel to allow the air to get through, as the stoker takes care of that.

There is a tendency in some plants where the load is light to run too many boilers and consequently too light a fire. Although this practice is not serious, it is somewhat wasteful. To get the best results, the fire should be of uniform thickness with no holes.

Starting the fire is simple. Green coal is fed into the stoker through the hopper, until the grates are covered. The operator should note how the coal feeds at each starting of a new fire. When the grates are well covered with coal, a few shovels of live coal will quickly ignite the fuel bed and the forced draft may be turned on gradually.

Probably the most important point to consider in the operation of an underfeed stoker is the proper supply of coal and air. This should be carefully studied and, once determined, the automatics may be adjusted to maintain it. Do not persist in throwing off the automatic control, because such a practice will cut the efficiency and increase the cost of operation. On the other hand, if conditions change and a new or untried fuel is being burned, use care in determining just what the mixture of coal and air should be and adjust the automatics to make that mixture and then let them alone.

As a general average, it is estimated that it takes 230 cu.ft. of air to burn one pound of bituminous coal. If the supply of air is not sufficient to burn the coal supplied, then some of the coal will be unburned and will be wasted through incomplete combustion and thrown away with the ash. If too much air is supplied, coal is being wasted in heating the excess air to the stack temperature and not getting the heat into the boiler where it should go.

be from nothing to eight per minute, it is a simple matter to adjust the supply to meet any given condition.

Generally 2 in. of draft will supply enough air to take care of four strokes per minute feeding 32 lb. of coal,

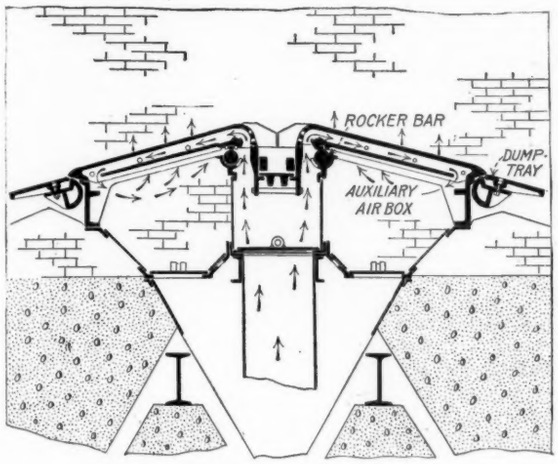


FIG. 2. CROSS-SECTION OF GRATE

so that practically all the carbon is burned out by the time the coal reaches the dump plates and nothing remains but ash.

The automatic regulation of both coal and air is obtained by means of a damper regulator that is sensitive to slight variations of steam pressure, acting on a balanced throttle valve on the blower engine or motor rheostat, so that when the steam pressure falls slightly, the blower increases in speed and, conversely, with the rising steam

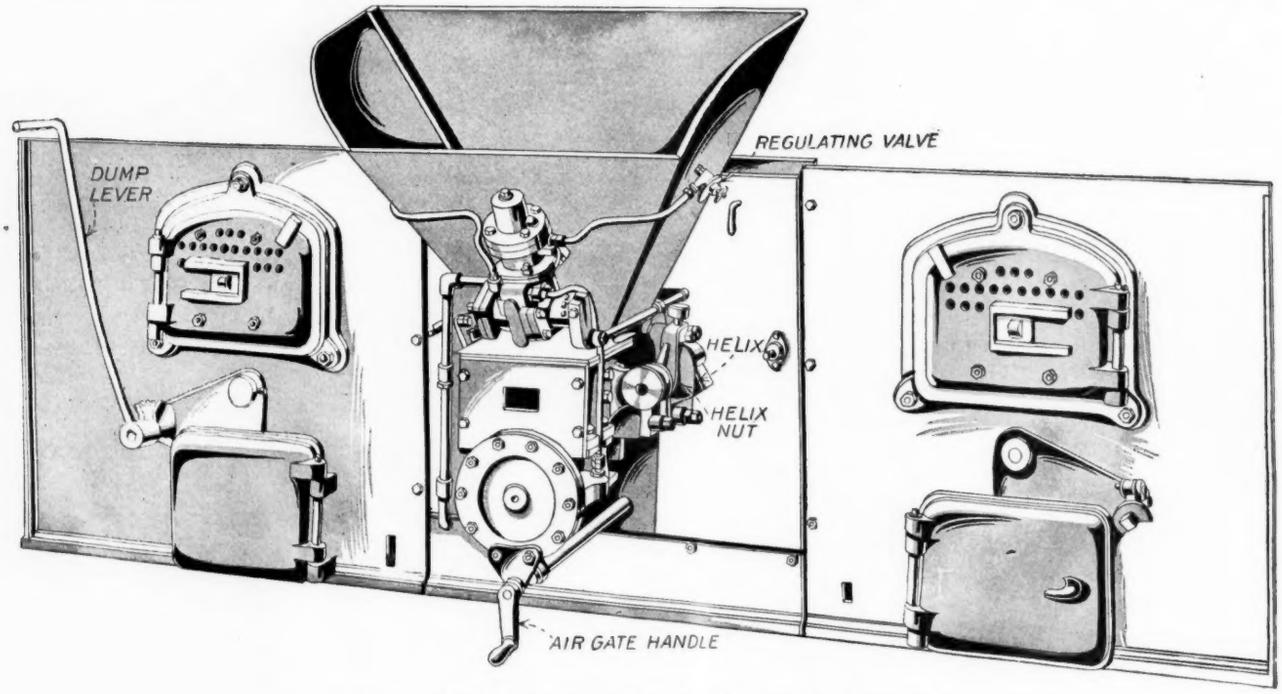


FIG. 1. HOPPER AND MECHANISM OF TYPE E STOKER

Care should be used to determine just how much coal should be fed to meet an available draft condition. This can be determined only by studying the conditions of the grates, the baffling and tubes and the general temperatures that can be obtained under different coal supply and forced draft. The coal pusher is designed to feed from 7½ to 8 lb. of coal per stroke, and as the strokes may

pressure the blower speed decreases. The variation in feeding the coal is obtained by a chain connection between the regulator and the valve controlling the stoker, so that with each variation in the steam pressure the amount of coal fed by the stoker is increased or decreased. In this way the proper proportion of air to coal is automatically maintained.

Care should be exercised to see that live coal does not accumulate on the dump plates, Fig. 4. This condition tends toward low temperature at that point and consequent fusing of the refuse in the coal into a solid clinker

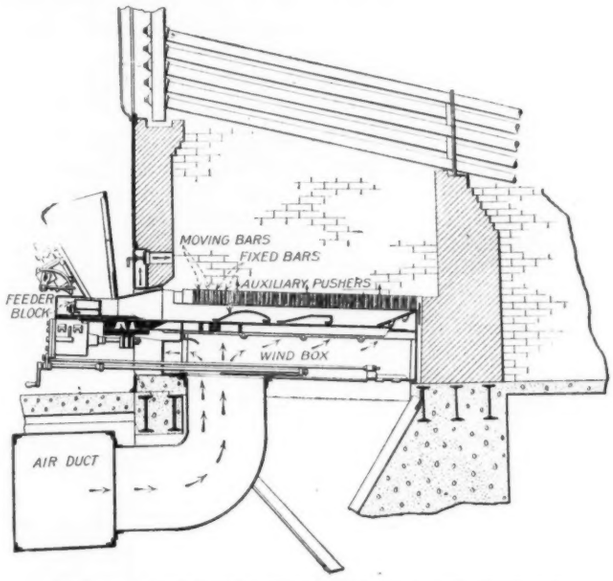


FIG. 3. A SECTION THROUGH THE CENTER OF THE RETORT

at the bottom. This makes for very hard dumping and consequent loss in the ash because of unburned coal getting into the ashpit. This is because when the dump plates are lowered the clinker hangs up in a mass, with some coals, and the use of a bar in knocking it loose causes live fuel to fall into the ashpit.

If by chance this condition of coal on the dump trays should happen, close the ashpit doors and open up the grids in the air box, putting the dump trays under forced draft, and at the same time stop the stoker feed until the combustible in the fuel along the dumps is at least partly consumed. The grids should be closed again as soon as possible. In such a case the dumps should be eased off a trifle to prevent growing into the side walls as the blast strikes them and makes the fire at that point excessively hot. If this is not recurrent at frequent intervals, it will be found that the brickwork is not injured. As a matter of fact, in emergency, when for any reason excessive rating is required for short periods, this is one way of obtaining it. It is seldom deemed necessary, however, as with this type of stoker ratings of above 300 per cent. continuously are not unusual and for short periods higher ratings may be obtained.

Under unusual conditions the best results will be obtained from a fire from 10 to 12 in. thick. If the stack draft is insufficient for a fire, it is folly to attempt to carry more fire than the stack draft will take care of. Every stack should be large enough to take off the products of combustion. If it is not, the furnace and fronts will become overheated and the brickwork and fronts will be high in upkeep cost.

The frequency with which fires are dumped, by means of a lever on the outside of the furnace, depends on the percentage of ash in the coal and the rate at which the boilers are being run. Generally, however, dumping should take place at least every two hours. If the plant is being run light and the ash in the coal is low, the periods may be slightly extended. It is a good thing, however, to keep the fire clean.

When a low fire is carried and it is found that for any reason unburned coal is on the dump plates, it may be winged back with a bar. This is a simple operation and worth the trouble in the fuel saved.

To bank fires, run the stoker very slowly, leave full blast on until the fire is well burned down. Then stop the stoker and continue burning down until all the fuel on the grates is burned out. Then shut off the air, dump the ashes and clean all ashes from the fire-bars. Next start the stoker and feed in enough coal for the required duration of the bank, after which close the boiler damper and ashpit doors.

Care should be used to see that all the parts of the stoker are properly working and an inspection frequently made to determine this. The adjustments are so few that there is no excuse for poor working conditions, and a slight adjustment may mean the saving of money both in fuel burned and in ultimate cost for replacement. Parts that show undue wear are not properly adjusted, and sometimes the tightening of a nut will ultimately save money, for it is by following instructions carefully that the life of the stoker is prolonged.

Discourage the use of the slice bar. Poking or hooking the fire is unnecessary. With sufficient draft and proper movement the heat will be so intense that this method is not needed. Always keep the fire as near incandescence as possible to obtain the best results.

The operator should remember that to feed more coal into the furnace than can be properly burned by the air supply is only feeding coal into the ashpit. Check up the air pressures frequently and know what the plant is doing. Not only will the most be gotten out of the stokers by doing this, but there will be a benefit from many other directions.

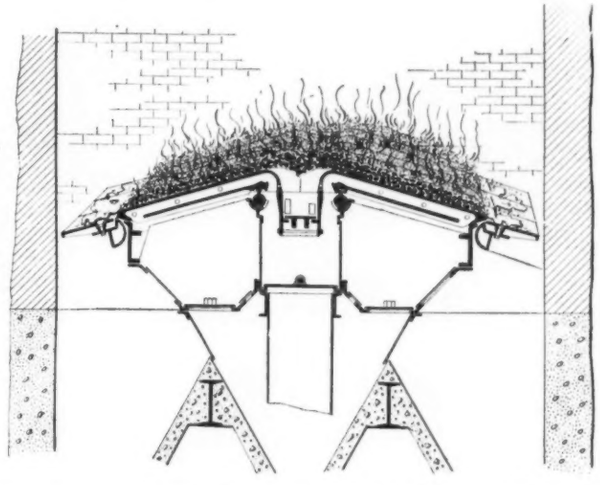


FIG. 4. FURNACE, SHOWING DUMP PLATES PARTIALLY COVERED WITH CLINKERS AND ASHES

Check, and at all times know, the amount of water that is being evaporated per pound of coal. Look over the automatics from time to time to see that they have not been tampered with or the adjustment changed. When anything is found that appears to be wrong and the remedy is not apparent, write to the manufacturer instead of asking someone who does not know but thinks he does.

Steam-Engineer's License Examination—XI

By H. F. Gauss

SYNOPSIS—How the direction of rotation of an engine is reversed. Simple explanations of the Stephenson link and the Gooch and Walschaert gears.

Generally speaking, the relative position of crank and eccentric on a steam engine must be such that when the engine passes dead-center in the direction in which it is intended to run, the eccentric moves in a direction to open the steam port. In a simple direct slide-valve engine, the eccentric is necessarily set ahead of the crank in the direction of rotation. The amount by which the eccentric is ahead of the crank, as explained in a previous article, is 90 deg. plus the angle of advance. Evidently, then, the position of the eccentric relative to the crank determines the direction in which the engine will run.

For instance, in Fig. 1, OA is the crank, and with the eccentric at B, the engine will run in the direction of the arrow C, while with the eccentric at D, the engine will run in the direction of the arrow E. To reverse the direction of running, it is necessary only to shift the eccentric position from B to D or vice versa, as the case may require, which would of course necessitate stopping the engine.

The Stephenson link motion is designed to accomplish the effect of shifting the eccentric, thus reversing the engine without the necessity of shutting down. This is accomplished by employing two separate eccentrics, keyed to the shaft, one with its center at B and the other with its center at D, Fig. 4. The ends of the respective

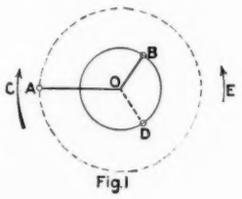


Fig.1

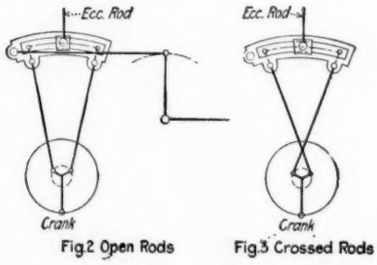


Fig.2 Open Rods Fig.3 Crossed Rods

FIGS. 1 TO 3. LINK MOTION REVERSING GEARS
Fig. 1—Relative positions of crank and eccentric. Fig. 2—Open eccentric rods. Fig. 3—Crossed eccentric rods

eccentric rods are joined together by means of a slotted link L. The slot in this link is the arc of a circle having its center at the center of the crankshaft. The end of the drive rod H terminates in a block that slides in this slot.

Link L is supported by the lever A, which in turn is carried by the bell crank G pivoted on the engine frame at C. The position of the link can be controlled by the bell crank, and evidently when the link is up and the eccentric rod F is in line with the block, this eccentric controls entirely the motion of the valve and the engine runs in the corresponding direction. On the other hand, when the link is down and eccentric rod E is in line with the block, this eccentric controls the motion of the valve and the engine will run in the opposite direction. In fact, any movement of the link in the direction of the stem moves the valve. When the block is at the middle of the slot, it is influenced equally by both eccentrics and

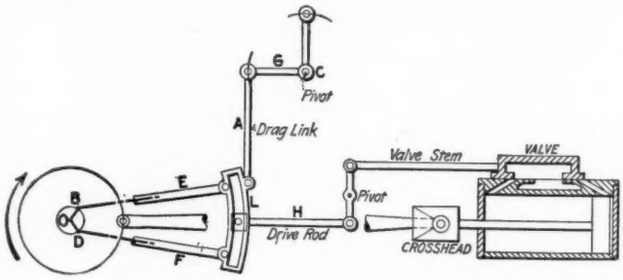


FIG. 4. STEPHENSON LINK ATTACHED TO SLIDE VALVE

the engine will not run in either direction. The nearer the block is to the mid-position in the slot, the less is the travel of the valve and the earlier in the stroke the steam is cut off. It is thus seen that the reversing gear serves a two-fold purpose—to reverse the engine and to vary the point of cutoff.

The motion of the various parts of the link during a complete revolution of the engine is the resultant of the movement due to the eccentrics and that due to the connection of the link with the radius bar, or drag link A. The end of the link connected to the radius bar will of course move in the arc of a circle about the pivot which connects the radius bar to the reversing lever.

If, with the engine on dead-center and the crank farthest away from the link, the eccentric rods do not cross (see Fig. 2) they are referred to as open. On the other hand, if the rods cross (see Fig. 3) they are said to be crossed. When the link is placed so that the block on the valve rod is in the middle of the slot no steam is admitted. To start an engine having an open link motion, as illustrated in Fig. 2, in a given direction, the link must be moved in the direction in which it would revolve were it connected rigidly to the crankshaft and turned with it, whereas to start an engine having crossed rods, the link must be moved in the opposite direction. The point at which the radius bar is connected with the link is determined by the direction in which the engine is to run most of the time. For instance, if the engine is to run "over" the greater part of the time, the link is suspended from a point as near as possible to that at which the forward eccentric rod is attached. This is due to the fact that on account of the complex motion of the link, there is a certain amount of rubbing of the block in the slot, and the nearer the block is to the point of suspension of the link the less is this action. It is for this reason that the link is usually suspended from a point nearest the forward eccentric rod, thereby reducing the wear and tear to a minimum for the working position of the link. Of course, when this is done, the slotting

action in backward gear is excessive, but the disadvantage is conceded to secure more perfect action in forward gear. When the engine is intended to operate as much in backward gear as in forward gear, the link is suspended from its middle point.

Another reversing gear is the Gooch gear, shown in Fig. 5. A point to be especially noticed is that the slot in the link K is convex toward the shaft instead of concave, as in the case of the Stephenson link. The radius of the slot is of a length equal to the radius rod L. Hence, with the engine on dead-center the block can be raised or lowered in the link without moving the valve. It follows that the lead is constant and does not depend on the length or connection of the eccentric rods.

By comparing Fig. 5 with Fig. 4, it can be appreciated that it requires a greater force to operate the Stephenson gear than the Gooch gear, and for stationary-engine purposes the Gooch gear throws a lighter and more easily balanced load on the governor. It might be remarked, however, that while in the early days of the steam engine the Gooch gear was frequently used, it has grown out of favor, but is a good illustration of the principle employed in reversing engines.

A third type of reversing mechanism is the Walschaert gear. While this is applied principally to locomotive engines, it should be understood by the stationary engineer. Fig. 6 is a diagrammatic sketch of this gear applied to a piston valve. As steam is admitted past the inside edges of the valve, the latter is therefore of the indirect type. Of course the mechanism can be equally well applied to direct piston valves and to ordinary slide valves.

The motion produced in the valve is the resultant of two component motions—that produced by the eccentric C and that produced by the crosshead D. In the illustration A is the mainshaft and B is the crankpin. The eccentric is formed by fastening the lever BC rigidly to the crankpin. The eccentric center C is exactly 90 deg. behind the crank, hence the angle of advance is zero, and were it not for an additional compensating device there could be

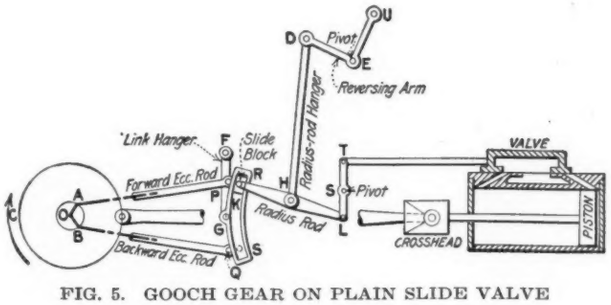


FIG. 5. GOOCH GEAR ON PLAIN SLIDE VALVE

no lap or lead to the valve, and steam would be admitted throughout the entire stroke. The link RS, pivoted at the fixed point K, is driven by the radius rod that carries the block J and is attached to the bell crank WYU at one end and to the lever HF at the other. The valve stem is attached to the lever HF at G, this lever being attached to the crosshead by the link FE. The lever HF is so proportioned that with the link block J in mid-position, the valve moves a distance equal to the lap plus the lead while the piston moves from head end to crank end or vice versa. This is the device which compensates for the zero angle of advance of the eccentric. To secure a constant lead, the radius of the slot in the link should be equal to the radius rod HJ and the various proportions must be such that with the piston at either end of the stroke, the arc of the link RS has H as a center. When this condition obtains, then for either dead-center position, the valve is not moved by shifting the block to any position in the slot, and the lead necessarily remains constant.

For the engine shown, if the block J is shifted to the lower end of the link, the engine will evidently run in the

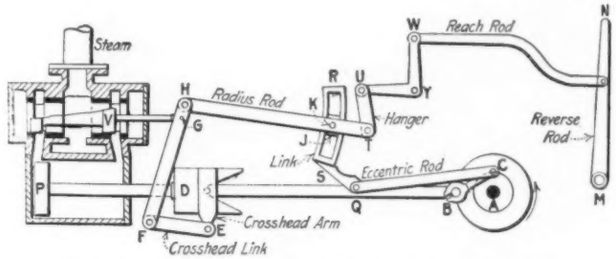


FIG. 6. WALSCHAERT GEAR AND INDIRECT PISTON VALVE

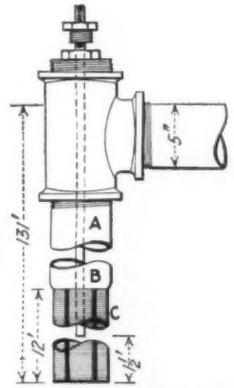
direction of the arrow. On the other hand, with the block in the upper portion of the slot, the engine will run in the opposite direction.

Valve gears of this type are generally referred to as radial gears, and there are a number of modifications on the market. As space will not permit a further description of them, the reader is referred to *Power*, Aug. 1, 1916, or to a book entitled "Valves and Valve Gears," by F. DeRone Furman, for a further simple concise discussion of the subject.

Strainer Cleaned with Steam

By Louis Wellenkotter

A well pump hammered and knocked at every stroke, and an examination showed its working parts to be in a first-class condition. It was also found that an insufficient supply of water in the well was the cause of the trouble, owing to particles of fine sand gathering around the outside of the strainer. A simple method arranged as follows, has been used to remove the accumulation of sand: A $\frac{3}{4}$-in. steam pipe A was connected and inserted in the well casing B, the lower end of the pipe reaching not quite to the bottom of the strainer C. At the top of the steam pipe a bushing was screwed on a long thread and another bushing in the tee permits of making a tight connection with the steam pipe and the well casing when screwed together.



STRAINER CLEANER

With all the connections made as shown and the suction valve closed tightly, we turn on steam at 110 lb. pressure for a period of 2½ hours. This removes the sand and does not injure the well casing, and a sufficient supply of water is obtained for the pump. The cost of this piping, including labor and material, was $10.50. If a new strainer had been put on, it would probably have cost about $175.

Injuries Producing Diseases

By Chesla C. Sherlock

SYNOPSIS—Something about the law governing disease as a result of injuries received by a workman while in the pursuit of his duties. A number of court decisions are given.

In many cases where a workman is injured through the negligence of his employer, disease results. Medical science has reached the stage where it not only determines the proper remedy for a malady, but it can also determine the cause of the disease attacking the patient. When a physician examines an injured employee and declares that his diseased condition is due to his former injury, a multitude of questions arise which at once vitally interest both the employer and employee. Naturally, the majority of these questions find their way into the courts for final settlement.

With the exception of casual legislation the vast majority of the laws applying in these cases is determined wholly in the courts. The law on diseases produced by personal injury has reached the point in this country where it is reasonably well settled. Of course newer light is being cast upon the subject daily, but both employer and employed can know with reasonable certainty just what their respective rights and liabilities are under this branch of industrial law.

Where an injury superinduces and contributes to the production or development of a disease, the person responsible for the injury is responsible for the disease. This proposition was first announced by the Maryland courts, when they decided as follows:

A cancer could not be treated as an independent cause of injury, since the original injury is to be regarded as the prime cause that opened the way to set other causes in motion which led to the fatal results.

In a case where one was injured by a fall and it was necessary to amputate a leg, the court said damages for the amputation should be properly assessed against the one liable for the fall, but if, in fact, the amputation was made necessary because the injured party was suffering from tuberculosis of the knee, such recovery should not be allowed. This latter proposition, however, is the center of some controversy. The courts have repeatedly held that the fact that the injured person was suffering from disease at the time of his injury was immaterial and that if the injury aggravated the disease and made it worse or produced other results that would not have been produced but for the injury, recovery would lie just the same.

An Iowa case held that catarrh might properly be found to be the result of an injury to the surface of the nose, when it was shown that the plaintiff had not suffered from catarrh prior to the injury. In Pennsylvania the court allowed the question of whether hemorrhages of the stomach resulted from an injury received three months prior to the hemorrhages to go to the jury. Hernia, or rupture, has likewise been held to be an element of damages.

Before going further with this discussion, it might be well to consider the effect of the workmen's compensation acts upon this class of cases. It should be remembered that under the compensation acts there can be no recovery for a purely industrial or occupational disease. By this is meant any disease arising as a result of long employment in hazardous occupations, as, for instance, copper poisoning. The purpose of this discussion is not to treat of those cases, and mention is here made in order not to confuse the reader. The cases here noticed are those resulting from injuries due to the negligence of the employer.

Appendicitis and peritonitis have been held to be the result of injuries. A Massachusetts case held that the employer could not escape liability for blood poisoning upon the theory that it is not ordinarily the result of a wound of the character which he had negligently inflicted. Damages for blood poisoning have also been allowed in Alabama, New York and Texas.

Damages have been allowed for loss or impairment of eyesight, although some courts have refused it. It is a question of strict evidence which, if clearly established, will permit of recovery.

Diseases Caused by Injury

Erysipelas resulting from a fracture constitutes a portion of the injury itself and therefore is an element of damages. It is none the less so, as one court said, because under similar accidents producing fractures that disease would not ordinarily ensue. In fact, where any disease can be shown beyond a reasonable doubt to have been produced in the particular case by the injury, it is an element of damages regardless of whether similar injuries ordinarily produce the same disease.

Gastritis was held to be an element of damages in a case where the employer negligently produced the injury which produced gastritis, in turn producing death. A New York case, which illustrates the manner in which the courts trace the disease back to the original injury, showed that the injury caused an abscess, the abscess blood poisoning, the blood poisoning gastritis, and finally, 16 months after the original injury, the injured person died of gastritis. In this case damages were allowed for the disease resulting from the original injury.

Opinion Divided on Heart Disease

The courts are divided as to whether heart disease is an element of damages. Where it can clearly be shown to have resulted from the injury, however, there is a good chance of recovery, but because of the nature of the malady this is not an easy matter to accomplish.

We might cite specific examples of various diseases almost without number, but that is unnecessary. Suffice it to say that, in addition to the diseases already mentioned, the courts have allowed recovery for paralysis, pneumonia, rheumatism, spinal afflictions and tuberculosis. Of course, where death results, recovery is allowed, but it is upon a different theory than the one under which recovery for disease is allowed.

In reaching these decisions the courts have only followed the conclusion that has come into the public mind in recent years; namely, that such losses should be considered a part of the cost of production and be borne by the one at fault and not by the party least able to bear it.

Editorials

Large Power Contracts and Increased Coal Prices

Under normal conditions large power loads at high load factors are much sought by the central stations, and in order to secure such business it has been found profitable to make contracts at rates only slightly in excess of production cost. With the present abnormal rise in coal prices, however, the situation has assumed an entirely different aspect, and there is no longer much profit in this class of business at many of the existing rates; in fact, it is believed that some are being met at a loss. But the contracts have been made and must be carried out.

In some quarters there is agitation to meet the situation by raising rates. This, it is argued, would be only fair inasmuch as there has been a general reduction in rates during the past two years. However, it must be remembered that this reduction has largely been in the maximum rates which affect the small consumers. Such customers have, as a rule, very low load factors, and the greater part of their rate covers an investment, or "ready to serve," charge. The increased cost of serving such customers, due to increased coal prices, is therefore relatively small considering their rates, and it would be eminently unfair to make the small consumer bear the whole burden. If rates must be raised in line with the tendencies of the time—and none would expect a public utility to do business at a loss—let the increase be apportioned equitably among the various classes of consumers.

All-Around Coöperation

That the big business interests are taking the right and patriotic stand in the present situation is shown by the hearty spirit of coöperation with the Government that is everywhere displayed. Committees composed of leaders in all branches are vying with one another in their efforts. Of the two ways of producing supplies and transporting them to points most in need, namely, voluntary team work or compulsion under governmental control—the former seems by all odds to be the right and chosen one. Those who have made an extended study of their particular lines, as well as those who have become masters of useful trades, should not be supplanted, but should be called upon to speed up—be put on their mettle to produce more and do better.

Secretary Lane, in the course of an address at the organization of the coal-production committee, said that his chief gratification, since the work of mobilizing the resources of the country had begun, was this spirit of coöperation on the part of bankers, railroad men, mine owners, engineers, lawyers and others—men of the largest capacities and incomes—tendering not only their own services, but their plants to the Government to meet the national need. A suggestion was thrown out in this address that engineers will do well to ponder; namely, the temporary relaxation of smoke laws, to urge it upon local city authorities in order to ease the increased cost burden of steam making as much as possible—simply as a war measure. This must not, however, be used as an excuse for slovenly practices in the plant, in which event the smoke nuisance may abound and the cost of steam increase at the same time, or for relaxation of laws pertinent to public health or safety. Good combustion and clear stacks go together, but the change from hard to soft coal in many cases can be made with comparatively little cost, although the temporary expedient cannot be expected to give the best of results either in economy or smokeless operation, but may cut the cost of steam considerably without being a nuisance. At any rate the choice of the fuel most available should be granted without unnecessary restriction and without causing anyone to feel like an outlaw or criminal when an honest effort is exerted to avoid making smoke.

The Standardization of Transformer Polarity

Whatever may be said against the standardization of electrical equipment and systems, owing to excessive expense, tendencies to discourage initiative or otherwise, cannot be said about the standardization of transformer polarity. It is regrettable that the alternating-current system in its development should have been burdened with such a multiplicity of frequencies and voltages, but it is even more so that the transformer, the most simple of important electrical equipments, should have been provided with no standard of bringing out the leads from the primary and secondary windings.

There are several large electrical manufacturers in this country who build transformers that range in size from a small metering equipment to those having capacities of ten thousand kilovolt-amperes and over, totaling per year a kilovolt-ampere capacity that is measured in hundreds of thousands. As a result of no fixed standard in such a simple yet important detail of construction as the relation between the primary and secondary leads, it is absolutely impossible for the electrical worker, unless he is already familiar with the make of equipment to connect two transformers of different manufacture together and know that they are connected correctly without first testing the polarity. Although polarity testing is not a difficult task to perform if the proper equipment is at hand, it is not a job that can be left to every workman. Likewise, for metering equipment what would be correct wattmeter connections with one make of transformer would be wrong with another. The outcome of neglect on the part of the manufacturers to adopt some standard in this simple detail of construction is endless confusion and mistakes by the men who make the installations.

The question of transformer polarity has been attracting the attention of the electrical-engineering societies for a number of years, but the limit of progress in this direction has been confined mostly to a standard system of marking the primary and secondary leads, adopted by some of the manufacturers, according to the recommendation of the electrical-engineering societies.

The Committee on Meters of the National Electric Light Association has recommended that the transformer leads be brought out so that the secondary and primary leads on the same side of the transformer will have the same polarity. This would seem to be the most logical recommendation, as such a relation in practice corresponds with the theory that the secondary current flows in the opposite direction to that of the primary. If it were not for any other reason than making practice correspond with theory, this recommendation is justifiable. In considering the construction features, there cannot be any serious objections to this system, since some of the electrical manufacturing companies adopted it in the beginning and have used it ever since. Therefore it would seem to be more of a case of the others starting the other way and not caring to turn back. However, the longer this continues the farther we are getting away from a real standard and the harder it will be to make the change if ever it is made.

Transformers are in such extensive use today that it will require years after all manufacturers and operators have decided upon some standard of polarity to completely attain this standard. However, the start must be made some time. No doubt in making the change it will cause more or less confusion, therefore some standard system of marking the leads, such as now recommended, will be necessary until such time as all transformers have been changed over to a standard polarity. The start in the right direction is up to the manufacturers, and after that it will be up to the operators to gradually change over all transformers that they have in service at such times as it is convenient, as when transformers are repaired or taken out of service and put into stock. The general adoption of this standard will ultimately result in the elimination of much confusion that now exists in the use of this type of apparatus.

Care of Ammonia Valves

There is probably no other kind of power-plant equipment that receives the amount of abuse that is given to ammonia valves. The average operator and workman around a refrigerating plant, when he has occasion to operate the stop valves on any part of the system, generally uses a wrench on them. Often the wrench is a necessity owing to the valves not being properly taken care of; but in many cases it is used when there is no need of it.

Many operators draw up on all the valve stuffing-boxes as soon as they smell ammonia around the place. The result is that whenever it is necessary to operate the valves, they are so tight that a wrench must be used on them. Sometimes valves are so difficult to move, the packing being screwed up tight, that it is almost impossible to tell when the valve comes to its seat. Sooner or later the disk, and many times the seat, is sprung so that it is impossible to make it hold tight no matter how hard the valve is screwed shut.

In most plants ammonia-valve stems, like those on most steam valves, are not repacked until it is impossible to draw them up tighter and they begin to leak so badly that something has to be done immediately. In addition, operators do not follow up leaking stuffing-boxes, and the stems become rusted, scored and cut until it is impossible to keep them tight for any length of time with the best of care and packing.

There are plants where a man would get his "passports" at once if he were caught using a wrench of any kind on ammonia valves. In such plants the valves are repacked every winter and the stems on those that are in constant use are kept well supplied with grease. Whenever a valve is opened, it is the invariable practice to spread the grease along that part of the stem that had come out of the stuffing-box, and for this reason the stems are never rusted. Those valves that are seldom used are painted with white lead, and if it is necessary to close them there is no trouble in doing so. Whenever one closes a valve, he should bring it down to the seat easily, then open it a turn or so and set it down on the seat again; this should be repeated three or four times. In this way if there is any scale caught under the disk it has a chance to work out, instead of grinding into the disk and seat, as is done when a wrench is used to close the valve.

There is no need to emphasize the importance of valves, those on an ammonia system particularly; but there is need to assert that chief engineers, as responsible heads of plants, should see to it that valves are properly installed and maintained.

A committee has been appointed in England to carry out a plan for raising a fund for the purchase of the scientific library of the late Prof. Silvanus P. Thompson as a memorial of his life and work, the library to be presented to the British Institute of Electrical Engineers as a permanent adjunct to the library of that Institute and to be accessible to the public. "The late Professor Thompson had so many friends, students and admirers in America, and was known to so many electrical engineers by his extensive and classical publications on electrical science and engineering, that the committee in England felt that it would be only a matter of courtesy and sympathy to open the subscription list to the American Institute of Electrical Engineers." Nothing can better exemplify the thought and genius of the man than the library that he has accumulated during the years of his experience; therefore, the electrical-engineering institutes are to be congratulated upon this opportunity to create such a fitting memorial to the life and work of so great an engineer and scientist as was Prof. Silvanus P. Thompson.

Prussia, following other states in the German Empire, is to nationalize its electricity supply. The British Board of Trade is considering it for England. We remember that Ferranti proposed such a thing years ago, and it was taken as Utopian. State electricity has its advantages; but here it will come soundest if it comes slowly.

War teaches many things, among them that most of the heat in a pound of coal, especially at present prices, can be put to better use than rejection to the sewer.

Correspondence

Cleaning Surface Condensers

Looking over *Power* for the week of Mar. 20, I became interested in the editorial regarding the performance and cleaning of surface condensers. There is no doubt that, since the advent of the turbine, which can economically use high vacuums, more and more attention is being paid to condensing apparatus. From an operating point of view the question arises, with the varying conditions throughout the year, just when is the condenser performance proper and what are the principal reasons for not getting as high a vacuum as desired?

Taking for granted that when the apparatus was first installed, everything was working properly and was well within the contract conditions, the thing that first troubles the operator is to find out what causes the falling off of the vacuum.

There are two important factors which practically tell whether the performance of a condenser is right or wrong: First, the amount of circulating water passed, which is indicated by the rise in temperature from the injection to the discharge; second, the difference in temperature between the exhaust steam and the condensate water. All other readings are of secondary importance, as they assist in locating the trouble if proper results are not forthcoming. In my experience with surface condensers I have found that the best results are obtained by passing all the water possible at all loads, and I believe this to be true almost without exception.

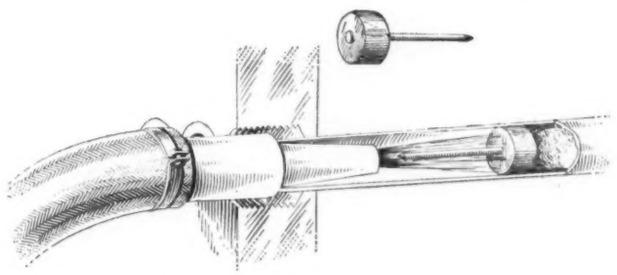
Following is a set of readings taken from the engineer's log at different periods of the year, before and after cleaning a surface condenser. These readings were taken from a 5000-kw. turbine and an 8000-sq.ft. surface condenser.

CONDENSER READINGS

Readings	Load, Kw.	30 In. Bar. Vacuum	Temp. Deg. F., Exhaust	Temp. Deg. F., Condensate	Temp. Deg. F., Injection	Temp. Deg. F., Discharge	Water Pressure in Lb. on Injection	Condition of Condenser
1	4,250	28.00	102	100	71	89	7.0	Dirty
2	4,300	28.36	96	93	70	87	3.5	Clean
3	4,600	27.65	107	106	79	98	5.0	Dirty
4	4,760	27.80	104	103	79	97	3.5	Clean
5	5,260	28.85	83	72	33	54	5.5	Dirty
6	5,300	29.00	80	64	33	53	3.5	Clean
7	4,900	27.60	110	92	72	91	3.75	Air leak
8	5,000	28.10	101	99	71	90	5.0	Leak repaired

The table gives results with different temperatures of injection water, and with condenser clean the performance is satisfactory in each case; it also shows quite a difference between the dirty and the clean condensers. One of the best telltales in this case is the increased water pressure on the injection. This pressure gradually increases as the condenser becomes fouled with foreign matter usually about as follows: The entrance of the first-pass tubes are found plugged more or less with small fish, grass, etc., and in all the tubes a slimy sediment forms a coating throughout their length.

Several methods were tried for cleaning this slimy sediment before one that was quick and effective was found. It was suggested to make small leather or rubber pistons, the size of the tube, which are held in an upright position by a sixpenny nail driven through the center. These pistons are placed in the ends of the tubes, with the nail trailing, by one man while another forces them through with water pressure. Using a hose with a special nozzle which enters the tube several inches and forms a joint on the end, the small leather pistons are forced through the tubes almost instantly as fast as they are placed in position. (See illustration.)



CONDENSER-TUBE NOZZLE AND LEATHER PISTON

The men work this method through the clean-out or handhole openings, and it is not necessary to remove the entire condenser head. These pistons are picked up from the other end of the condenser and can be used many times. Two men clean this condenser, containing 2592 tubes, in approximately 10 hours at a cost of $7.50 for labor. The pistons are from $\frac{1}{8}$ to $\frac{1}{4}$ in. thick and are punched out of scrap rubber packing and old leather belting. This method cleans the condenser thoroughly and as well as by swabbing.

It is interesting to notice readings 7 and 8 in the table before and after repairing a leak in the copper expansion joint connecting the turbine and condenser. The vacuum began to fall off gradually, and the difference between the exhaust steam and condensate water gradually increased. In the readings it is 18 deg., an evidence that the air was not being taken care of. In other words, it showed that there was an air leak or that the air pump was not working properly. The pump was examined, tested and found to be in good condition and from all indications working properly.

On examining all pipes, joints, etc., an air leak was discovered in the expansion joint. After this was stopped, the vacuum was immediately brought back to normal, the difference between the exhaust temperature and the condensate being within two degrees.

In readings 5 and 6 the difference in temperature in the exhaust steam and condensate is 11 and 16 deg. respectively; however, the vacuum is exceptionally good. This is due to the cold injection water and is proper, as a small rise in temperature on a cold injection gives a higher vacuum and the higher vacuum makes each pound of air occupy more cubic feet.

The air pump has a fixed capacity in cubic feet, hence the weight of air removed per hour is less, and at the

higher vacuum naturally more air enters the system, and as the pump's capacity in cubic feet per hour is limited, the difference between the exhaust steam and condensate temperatures will become greater with the colder injections and higher vacuums.

This simply means that an air pump that is an ideal size for 28 in. of vacuum would be too small for 29 in. and too large for 26 inches. L. J. SCHRENK.

Detroit, Mich.

Benefits from a Steam Separator and Reservoir

On taking charge of the plant here, I found that the engine, a 26 x 48-in. Corliss type, had not been indicated since it was erected. Diagrams, Fig. 1, show

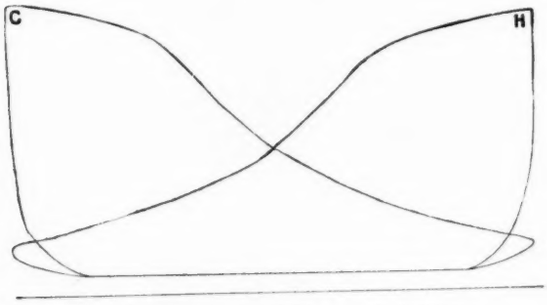


FIG. 1. EXCESSIVE DROP IN STEAM LINE

a big drop in the steam line, practically 25 lb. at cutoff. There was a small separator above the throttle, but one could hear that the steam was passing through it at a high velocity, so I had a separator made as shown in

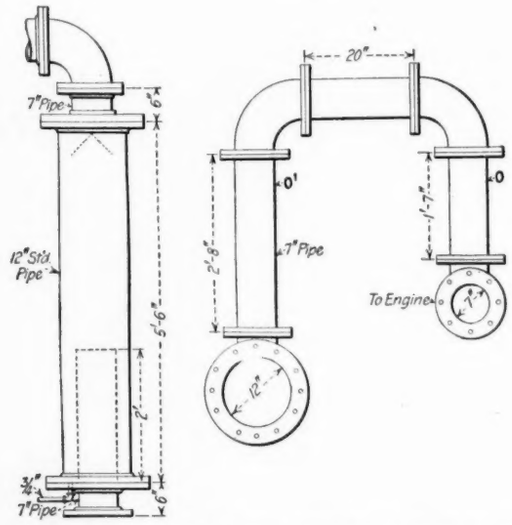


FIG. 2. DESIGN OF PIPING AND NEW SEPARATOR

Fig. 2, and then obtained diagrams as shown in Fig. 3. There is still considerable drop in pressure, but I attribute this to the so-called expansion joint shown in Fig. 2, suggested by an inspector, as the law says that there must be some provision made for expansion; but I guess he lost sight of the fact that the header and all piping were free to expand in either direction as there are no anchors. I believe the two pieces of pipe *O* and *O'* and an elbow could be done away with and a gain of 5 or 6 lb. in steam pressure at the engine be obtained, with no more

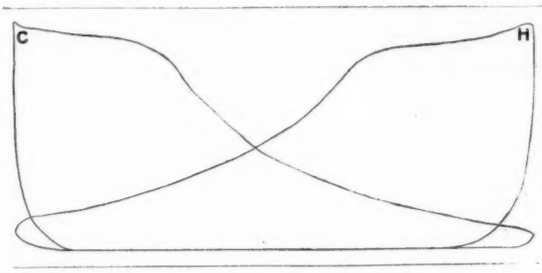


FIG. 3. IMPROVED DIAGRAMS WITH LARGE RECEIVER

danger than at present, as there is entirely too much vibration caused by the short bends. L. A. COLE.

Blacklick, Ohio.

Opportunity of the Engineer

Much thought and energy are being expended in efforts to assist the power-plant engineer with only a grammar-school, or at the most a high-school, education to better himself in his profession. The engineering magazines are full of educational articles, and evening, correspondence and other special educational means are available at little or no expense, so that ambition to rise, persistent application and good health are the chief requisites.

These opportunities are of vital importance and count in the making of better engineers. One phase of educational work is, I believe, sadly overlooked and neglected, and this neglect is responsible for the fact that many men rise to a certain point and then stop or find themselves badly handicapped by a warped, one-sided condition on account of their inability to express themselves in good correct English, write a correct business letter or converse on subjects outside of engineering.

Of course every engineer reads the newspapers and can tell much about the more prominent current events, but comparatively few read any standard literature. Having had considerable experience with power-plant men, particularly along the lines of education, I wish to make a few suggestions, for it seems a great pity that men with such possibilities should only half develop themselves.

One of the first assets that a broad-minded, well-developed engineer should have is the ability to express himself clearly and correctly in good English—not as an orator or public speaker, but having an idea to convey to another, he should be able to express that idea in words that will make it plain, and this without an abnormal use of slang. A certain amount of slang has found its way legitimately into the English language, but its too frequent use has greatly diminished its effect and force. Forcible expression without slang or profanity always commands respect and attention.

Correctness and clearness of speech may be acquired without great difficulty by anyone with ambition and persistence. Many books contain valuable hints, giving examples of proper expressions and the way to use the different parts of speech correctly—books written briefly and simply, as aids to correct English.

One of the best ways to acquire correct speech is by reading good literature—history, travel, biographies and

fiction by the best authors. These books should not be skimmed through, but should be carefully read, not only for the message which they are supposed to convey, but to learn by example the different ways in which ideas and thoughts may be correctly expressed and as a means of increasing one's vocabulary; and the meaning of any new word should be learned. A dictionary should always be at hand and referred to in this work.

Listening to and talking with correct-speaking persons is one of the best ways of learning the proper use of words and expressions, and many a man has not only added to his knowledge, but made himself an easy, convincing speaker by such profitable discussion.

An engineer should be a clear, rapid and accurate thinker—if the suggestions given are to be of value to the reader he must think—whether studying an engineering subject, reading a novel or discussing politics with a friend, his mind should continually be on the alert, taking in and storing up knowledge of facts and methods. If he is wise and does not keep to the same task too long, he will not feel mental fatigue—a change of occupation is restful.

The work of the operating engineer places him at a distinct advantage, for much of his time may be used with great profit to himself in study and good reading if he so desires. I believe that purely engineering subjects should be dropped for at least one-third of the time. Public libraries place an almost unlimited variety of books at his disposal, and librarians will gladly make helpful suggestions if he is uncertain as to what is wanted. Some may have to acquire a taste for good reading, but it can be done. Although it may require application and be regarded somewhat as a study at first, it will soon become a pleasure, broadening the mind for something higher and better. THEODORE H. TAFT.

Boston, Mass.

The Coal Problem of Today

Much has been said about the coal problem and probably some good has been done, but how is coal usually bought? Is the coal man told what you must have, and is it put into the contract, or is it left to him to decide? Most contracts are for so many tons more or less a year at so much per ton. Nothing is said about the standard of comparison or the limit of moisture the coal shall contain. If weighed at the mine, it is full of moisture; in fact, at some mines water may be seen dripping from the cars shortly after being loaded.

There are two things that should be done in large- or medium-sized plants. The first is to install a scales and make the contracts read, "Weights at power plant to be taken." The weight at the mine is from 800 to 1500 lb. per car heavier than at the power plant. Our scales shows a gross weight sometimes 1000 lb. less than that at the mines, representing the moisture lost en route, but cars received in rainy weather are nearer the mine weights. The second remedy is to buy on the B.t.u. basis. With your own scales and your own analysis you will be in a position to know what you are paying for.

In a recent issue of *Power* Mr. Hyde (page 162, Jan. 30; see also page 264, Feb. 20) said that dealers would not sell on the B.t.u. basis. This is because it would show what kind of refuse they were selling for coal.

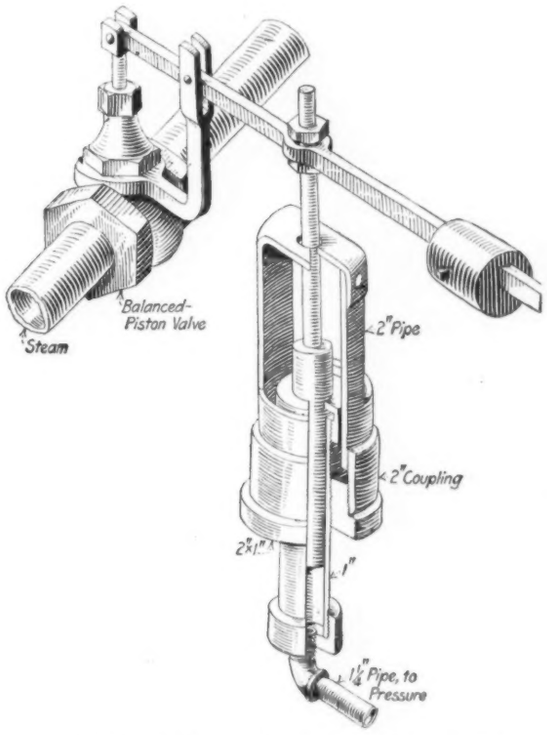
The coal question is becoming more of a problem every year, and the man in charge of an isolated plant should conserve his supply and see that his company gets a dollar's worth of coal for every dollar spent.

Xenia, Ohio. A. C. ELDER

Emergency Pump Governor

The illustration represents an emergency pump governor constructed of standard pipe and fittings, with the exception of two parts which can be easily made on a lathe. We built this for emergency use, but it operated so well that it has been kept in service for over three years.

It consists of a 1-in. nipple 6 in. long with a cap tapped for ¼-in. pipe on one end, and about 2 in. of thread on



GOVERNOR CONNECTED TO STEAM LINE

the other, to which is screwed a 2 x 1-in. bushing. A 2-in. coupling is cut in half and screwed on the bushing with sufficient thread extending to allow a piece of 2-in. pipe to be entered. This 2-in. pipe is prepared by sawing out two segments on opposite sides to within 1 in. of the threaded end and is made up into a yoke forming a guide, as shown. The plunger was made from a worn-out valve stem and slips easily into the well. A rod is screwed into one end of the plunger, passes up through the yoke and extends through an oval hole in the valve lever, with two nuts to allow for adjustment. The packing gland was made from an old valve gland bored out and threaded to fit the 1-in. pipe which forms the well. The pressure adjustment is accomplished by moving the weight on the lever and secured with a setscrew. The valve in the steam line is of the standard balanced piston type. The apparatus is supported by a strap bolted to the yoke and passing around the steam line—not shown in the illustration. The operation is evident, and results are satisfactory. H. M. NELSON.

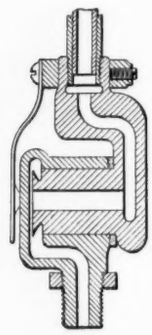
Shrewsbury, Mo.

Telescopic Oiler Discussion

Referring to the discussion of telescopic oilers,[1] I have one on the eccentric strap and one on the wristpin of a 20 x 30-in. engine running at 150 r.p.m., and for two years they have been in continuous operation without any trouble whatever. If these oilers are properly installed with a good check valve on the feed and the oil is not too heavy, they will work satisfactorily and last indefinitely. If Mr. Walker will use a light ball check or, better still, an automobile sight-feed fitting with a check valve combined, in the feed to the oiler, it will obviate all the trouble, as the weight of the incoming oil will overcome the pumping motion of the air. If the oil used is very heavy, it will not pass some of the check valves used and therefore will not feed down. A. A. BLANCHARD.

Ringwood Manor, N. J.

I do not agree with Mr. Walker, for we have an 18 and 30 x 42 cross-compound Corliss engine running 120 r.p.m. with telescopic oilers on crosshead pins and double eccentrics, and they are much superior to the wipe oilers we have on a simple engine. I believe that if Mr. Walker will change the fiber washer to be found in the lower swing joint and put in one a little thicker, his oilers will quit pumping and go to oiling, as ours did. The washer referred to is shown at the right in the sectional view. If worn too thin it will restrict the oil passage at the left to such an extent as to cause the oiler to overflow and if the washer material happens to be too soft it will soon wear down.



LOWER END JOINT

Red Oak, Iowa. L. W. EATON.

I have used telescopic oilers for years and have had no trouble with them. Oil cannot be run in a stream through them, but by feeding it drop by drop there is no trouble if the hole in the crosshead pin is not stopped up and there are clear oil channels in the boxes. If the oil pipes fit loosely, there is no chance for a vacuum or compression. FRANK WELLS.

Jeffersonville, Ind.

Expensive Patching Compound

Some weeks ago a salesman tried to interest me in an alleged original compound for stopping all kinds of leaks in water, gas, steam and ammonia piping; and feeling sure that I would recommend it to my friends if a fair trial proved its merit, he left a sample with me, some of which I used on a cracked pump cylinder. It stopped the leak satisfactorily, just as putty, paint or pitch would if used in the same way. The crack was opened, some compound was forced in and the crack drawn together with a through bolt which did not interfere with any working part of the pump.

The compound consisted of a powder and a liquid to be mixed to the consistency of putty and forced or calked into the crack or hole to be stopped. The liquid so much resembled glycerin that I tasted it and found it sweet. The druggist confirmed my opinion. It was glycerin. I had never seen outside of a paint store any powder resembling in color the one furnished, but its weight and its association with the glycerin made me think of litharge, which is an oxide of lead, and often used when a strong, quickly setting waterproof cement is wanted.

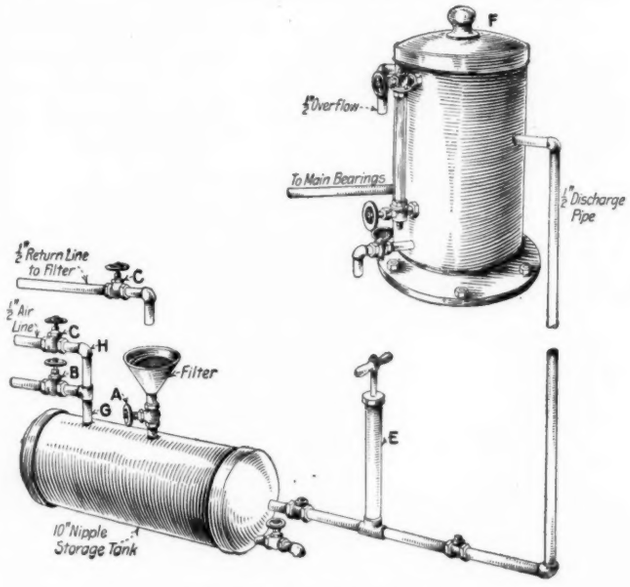
To satisfy my suspicion of its being litharge, I ran the point of a large drill into a bit of firebrick, poured about a tablespoonful of the powder into and around the hole in the bit of firebrick and put it in an extemporized muffle furnace made from a few firebricks. I then turned the flame of the shop blowpipe into the muffle and waited. In about half an hour the powder had disappeared, but in the cup-shaped hole in the piece of firebrick there rested a pretty lead button weighing about half an ounce.

I was satisfied. The compound is principally litharge and glycerin, which make an excellent cement for many purposes but hardly worth, even at war prices, the dollar and a half asked for a one-pound can.

New York City. F. L. JOHNSON.

Handling Oil by Compressed Air

The sketch shows a convenience that I applied to an engine recently, which may prove valuable to others. This engine was not provided with means for returning the lubricating oil to the overhead tank. We first made a filter tank, using a 10-in. nipple 24 in. long and two caps; holes were drilled and tapped for the pipes as shown. Having a branch of the factory compressed-air system in the engine room, we piped it to the tank at *G*, so that when the tank *F* is becoming empty and the filter tank is filling up, all that we have to do is to close the valves *A* and *B* and open the air valve *C*. In about ten seconds the oil is transferred from the lower to the upper tank. Then, by closing the valve *C* and opening *A* and *B*, the lower tank fills again. A hand-pump *E* was put in the discharge line for use in case the air supply should fail. If the facilities for making the hand pump are not available, a tee may be fitted at *H*, to which an ordinary automobile tire pump can be connected.



OIL TANKS AND PIPING

Indianapolis, Ind. WILLIAM HAYS.

[1] See page 463, Apr. 3, and page 707, May 22.

Inquiries of General Interest

Steam Required for Gas Producers—What is considered average practice as to the amount of steam required for a gas producer? B. D. A.

This depends on the kind of fuel used. Fuels containing considerable moisture, such as lignite or peat, may require little or no steam to keep the fuel bed temperature below the fusing point of the ash. With anthracite and bituminous coals, however, average practice varies from 0.25 to 0.75 lb. of steam per pound of fuel fired, the smaller figure applying to down-draft and the larger figure to up-draft producers.

Less Danger from Water When Running Without Compression—Is an engine more likely or less likely to be wrecked by water from the condenser if the valves are set for no compression of the exhaust? C. N. F.

Wreckage from water in the cylinder would be less likely with the valves set for no compression of the exhaust, for then the exhaust valves would remain open until the very end of the stroke and thus afford an outlet through which the piston might expel the water in place of gathering it up and completely filling the cylinder with water ahead of the piston.

Relative Heating Value of Return Tubes—Which tubes of a horizontal return-tubular boiler transmit greater amount of heat to the water of the boiler? A. H.

The heated gases in passing under the boiler and returning through the tubes have easier passages to tubes in the middle and upper rows than in the abrupt return to the tubes in the lower rows. Hence there is greater velocity, greater volume of the heated gases is presented to the surfaces of the middle and upper rows of tubes and more heat is transmitted through them to the water per square foot of heating surface than through the lower tubes.

Discharge Lines from Traps—Can two or more steam traps discharge into a common return main connected with a receiver, or should each trap have a separate discharge line? P. M.

A common return main can be used provided it is of sufficient size to receive the discharges of all traps operating at the same time without accumulation of more back pressure than any of the traps can discharge against. Where there is much discrepancy in the discharge pressures, a common main needs to be so large to prevent undue back pressure from steam discharged into the main that usually it becomes more economical to provide separate discharge lines.

Capacity of Blower for Forced Draft—For a forced draft what should be the capacity of a blower per pound of coal burned? W. K.

Most fuels require 11 to 12 lb. of air for combustion of a pound of the fuel, but to insure the supply of an abundance of oxygen, it is necessary to admit more air into the furnace than actually required for combustion. The amount of excess air required for best results depends on the draft; the weaker the draft the more excess air required. With chimney draft it is usual to supply 100 per cent. and with forced draft 50 per cent. of excess air. A pound of air at 62 deg. F. has a volume of 13.14 cu.ft., and allowing 11.5 lb. of air necessary for combustion of average coal, the capacity of a blower for forced draft should be $1.5 \times 11.5 \times 13.14 = 226.7$ cu.ft. per pound of coal burned.

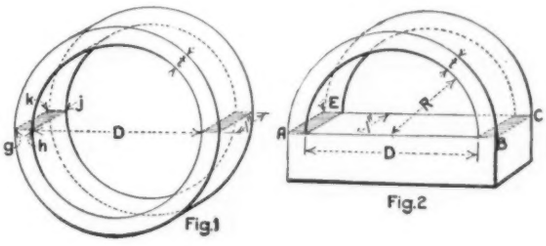
Obtaining Equal Cutoff Without Indicator—How can equalization of cutoff of a Corliss engine be obtained without using an indicator? W. D. C.

Block up the engine governor half way in the slot to determine whether the reach-rod lever stands at about 90 deg. with a line drawn midway between the reach rods. Place the engine on either center and make a mark on the crosshead to correspond with another on the guide. Then place the piston at about one-quarter stroke and make another mark on the guide to correspond with the mark on the crosshead and gradually block up the governor until the steam valve that is under control is tripped by the cam.

Next turn the engine over to the other center and place the piston at the same fraction of the stroke as previously employed for the other end of the cylinder by obtaining the same distance between marks made on the guide to represent the fraction of stroke taken. Then adjust the length of the reach rod by lengthening or shortening it as may be necessary, until the valve is just tripped. Equalization of cutoff will thus be obtained for the fraction of stroke of piston that was taken but, on account the variation in relative angularity of the connections for different positions of the governor, precisely the same relative equality of cutoff cannot be maintained when cutting off at other fractions of the stroke. If a closer approximation to equalization is desired for the average load the governor should be blocked to the position where it stands when running, and then, finding what length of stroke from one end of the cylinder is required for tripping the valve at that end, the engine should be turned to the same fraction of the stroke of piston from the other end and the reach rod adjusted to trip the valve.

Formula for Working Pressure for Longitudinal Joint—How is the formula derived for the safe working pressure for the longitudinal joint of a cylindrical shell, and why is the radius used as a divisor in place of the diameter? F. D.

Assume a cylindrical ring, such as shown in Fig. 1, to be 1 in. long and D inches in diameter, and assume Fig. 2 to represent a half-ring equal to the upper half of the ring, Fig. 1, joined to a very thick flat plate ABCE, Fig. 2, taking the place of the lower half of the complete ring, Fig. 1. If in each case there is the same internal pressure per square inch, the total pressure tending to separate the upper half from the lower half of the ring, Fig. 1, would be the same as the total pressure tending to separate the half-ring from the plate ABCE, Fig. 2. But the latter pressure will be equal to the total pressure tending to separate the plate ABCE from the half-ring to which it is attached; that is, will be equal to the number of square inches of area of the flat plate that is exposed to internal pressure, multiplied by the pressure per square inch. Hence if the pressure per square inch = P, the total pressure tending to separate the upper half from the lower half of the ring, Fig. 1, would be $D \times 1 \times P$, and the



"hoop stress" in a single cross-sectional area like ghjk, Fig. 1, would be $\frac{1}{2}$ of $D \times 1 \times P$.

To resist this stress with safety, the cross-sectional area of the section, in square inches, multiplied by the tensile strength of the material, in pounds per square inch, must be equal to $\frac{1}{2}$ D × P multiplied by the assumed factor of safety. Therefore, if D = diameter in inches, P = working pressure in pounds per square inch, FS = factor of safety, TS = tensile strength of the material pounds per sq.in., and t = the thickness in inches, then it follows that $\frac{1}{2}$ D × P × FS = TS × t, and the allowable safe working pressure would be

$$P = \frac{TS \times t}{\frac{1}{2} D \times FS}$$

But as one-half of D is equal to the radius R, the formula usually is written

$$P = \frac{TS \times t}{R \times FS}$$

and where E = the per cent. efficiency of a longitudinal joint, the formula for safe working pressure becomes

$$P = \frac{TS \times t \times E}{R \times FS}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

The Relation of Port Area to the Power of Gas Engines*

By J. R. Du Priest

SYNOPSIS—In the paper of which this is an abstract the author has given the results of an extended study of the working of a 16½ x 24-in. horizontal double-acting tandem throttling gas engine running on natural gas at 180 r.p.m., and from a consideration of the data obtained in tests and the characteristic curve of the governor used, he has devised a method by means of which the relation between the travel of the governor collar and port area for a given power can be determined.

The function of a constant-speed governor on an engine is to control the speed within certain limits, depending on the class of service for which the machine is designed, while the load varies anywhere within the capacity of the engine. The ideal method of governing would be some system by which the change in load could be anticipated at the proper instant and the energy supplied to the engine varied to suit the change in load, thus keeping the speed of the engine constant throughout the full range of load. This condition cannot be realized since it is impossible mechanically to anticipate such changes. Nevertheless, the speed of the engine must be held within the limits required by the condition of operation, by some suitable governing device.

In all types of governors dependency is placed on a change in speed of the governor to effect regulations, and when this governor is driven from the main engine, the speed of the engine must change before the governor can act or the valve gear can exert an influence over the energy supplied. If the load on the engine increases, the order of changes in the governor system is as follows:

ORDER OF CHANGES IN GOVERNOR SYSTEM

a. The speed of the engine decreases.

b. The speed of the governor is reduced.

c. The change in the position of the governor, due to the change in speed, shifts the valve gear and supplies more energy to the engine to enable it to carry the increased load, and at the proper speed.

d. The speed of the engines increases, owing to the increased supply of energy, hence the speed of the governor increases and the cycle described is repeated in reverse order. This action tends to produce a "hunting" effect on the valve-gear and governor until the energy supply is properly proportioned to the existing load.

The amount the valve-gear is moved for any slight change in speed of the engine and governor depends on the sensitiveness of the governor, its energy capacity and the mechanism connecting it to the valve-gear.

If the valve, in responding to an increased load, opens too far and supplies more energy than is necessary, the speed of the engine will rise above normal and the governing system will then reverse its operation and keep seeking a position of equilibrium, producing the objectionable hunting effect characteristic of too sensitive a governor.

Apparently the most desirable results would be obtained if the governor were so connected to the valve-gear that equal movement of the governor collar would correspond with equal changes in load.

It might appear that any degree of regulation desirable could be secured by using a very sensitive governor, but it has been found by experience that in some cases—particularly in gas-engine work—highly sensitive governors do not give as good results as those that allow a greater range in speed and do not respond so quickly to slight but sudden changes, because a sluggish governor, being more stable, tends to eliminate the hunting action. Fortunately for all ordinary work, the allowable speed variation is great enough to permit the use of stable governors.

In the regulation of the steam engine, where the steam is supplied under high pressure to the valve, the head producing flow through the ports and also the energy in a cubic foot of the steam entering the cylinder are practically constant because the boiler pressure and the quality of the steam remain essentially the same, but in the gas engines the conditions are very different. The energy supplied to the gas engine is in the form of a combustible mixture of air and gas, the quality of which may vary considerably, and also the head causing flow through the port varies with every change in load, if it is a throttling engine.

In the four-stroke-cycle gas engine the fuel mixture is made to flow into the cylinder by lowering the pressure in the cylinder below that of the atmosphere during the suction stroke, thus creating a difference of pressure sufficient to force in the charge.

The absolute pressure in the cylinder depends on the quantity of mixture entering the cylinder during the suction stroke. The amount of charge necessary in the cylinder depends on the load the engine is carrying, and therefore it is evident that a different amount is required for every change in load. Hence the absolute pressure in the cylinder during the suction stroke will differ for every different load, and the resulting pressure head causing the mixture to flow into the cylinder will be different.

This point can be most easily understood by neglecting temperature changes occurring during the suction stroke and assuming that the volumetric efficiency is merely a function of the difference between suction and atmospheric pressure.

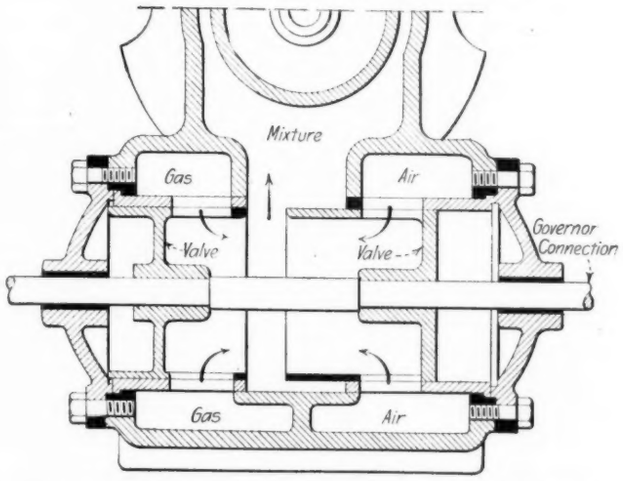


FIG. 1. SECTION THROUGH THROTTLE VALVE OF A HORIZONTAL DOUBLE-ACTING GAS ENGINE

If a load calls for a small charge, it must correspond to a low volumetric efficiency. The low volumetric efficiency is always accompanied by a low suction pressure, due to the throttling at the valve; therefore we have the peculiar condition that the greatest difference in pressure is available to cause flow when the least amount of mixture is required.

The result of this change in absolute pressure in the cylinder is such that when an engine is operated at, say, three-quarters load with an apparent volumetric efficiency of about 67 per cent. and a change in load occurs which demands a volumetric efficiency of 77 per cent., it will require a much larger port area to give the increase of 10 per cent. in volumetric efficiency at the heavy load than it would if the increase were from 30 to 40 per cent.; the reason is that in the first case the head causing flow through the port will be about 3.5 lb. per sq.in., while in the second case it will be about 7.5 lb. per square inch.

On account of the greater head causing the charge to flow into the cylinder at light loads, it requires but a small change in port area for a considerable change in load; therefore any system of connecting up the governor to the throttle valve that gives equal changes in port area for equal changes in the governor speed will make the regulation of the engine very sensitive at light load and too slow at heavy load.

The test hereinafter described was made to find out as near as possible (1) the conditions under which the fuel mixture enters a gas-engine cylinder and (2) the relation

*Abstract of a paper, "The Relation of Port Area to the Power of Gas Engines and Its Influence on Regulation," presented at the spring meeting of the American Society of Mechanical Engineers, Cincinnati, Ohio, May, 1917.

of port area to horsepower and its influence on the regulation of the gas engine. The results from the test are worked up, and an effort has been made to apply theory to the changes taking place, and thus find a means of predicting similar results for engines of the same type, before the machines are built.

The engine tested was a 16½x24-in. horizontal double-acting tandem engine operated on natural gas. The test was made in the following manner: The throttle valve on the head end of No. 1 cylinder was disconnected from the governor and operated by hand, while the other three valves, under the control of the governor, took care of the load on the engine. The throttle valve, shown in Fig. 1, is cylindrical, with six rectangular ports cut around the periphery, which mate with similar ports cut in the surrounding sleeve when the valve rotates. The throttle valve is made to open and close in unison with the poppet inlet valve and is moved longitudinally by the governor to effect regulations. The travel of the valve was 2.5 in. and 15 different settings were made varying from closed to wide open. Two sets of indicator cards were taken from each setting, one for indicated horsepower and the other for suction, two or more cards for each set being taken for every position of the vavle. The results from these cards are given in tables in the paper, and curves other than given herewith are respectively as follows: Indicated horsepower against port opening in inches; indicated horsepower against

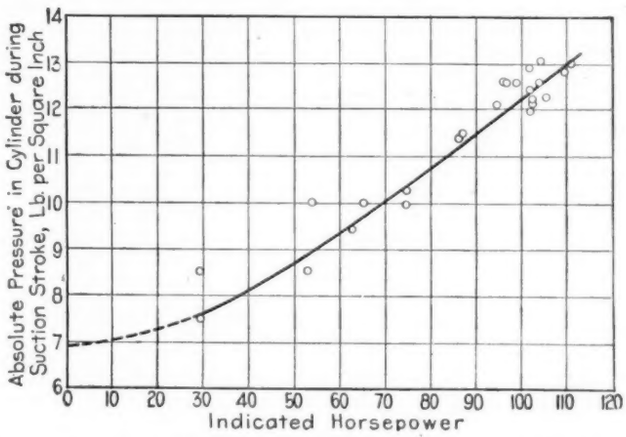


FIG. 2. INDICATED HORSEPOWER AND PRESSURE IN CYLINDER DURING SUCTION STROKE

apparent per cent. volumetric efficiency; apparent per cent. volumetric efficiency against port opening in inches; cylinder pressure, pounds per square inch absolute, during suction stroke against port opening in inches; absolute pressure, pounds per square inch, in the cylinder during the suction stroke against per cent. volumetric efficiency.

After the test was over and the load was removed, several indicator cards were taken with the engine running at the proper speed and all valves properly connected, but with only one cylinder end firing. These cards gave an average of 64 i.hp. for total engine losses, which consisted of machine-friction losses and the lower-loop losses.

From Fig. 2 the absolute pressure in the cylinder during the suction stroke for 64 i.hp. is 9.65 lb. per sq.in.; and with atmospheric pressure equal to 14.2 lb. per sq.in., this means that as the piston is moved out on the suction stroke, there is a resistance of 14.2 — 9.65 = 4.55 lb. per sq.in., due to the pump action.

In overcoming this resistance during the suction stroke the piston does work at the rate of 4.55 × 1.07 = 4.87 hp., which is a direct loss. (The factor 1.07 is the horsepower constant for one cylinder of the engine.) A loss of 4.87 hp. per cylinder end gives 4.87 × 4 = 19.48 hp. loss for the engine. Hence the machine friction = 64 — 19.48 = 44.52 hp., or 11.13 hp. per cylinder end.

If the machine friction for this load is assumed constant for all loads, which is rarely true, the delivered horsepower for any load can be determined from the indicated horsepower by subtracting the loss due to the suction stroke as measured by the suction card and the loss due to the machine friction. The maximum indicated horsepower for one cylinder end is 105, and from Fig. 2 the lower-loop losses for this load are 14.2 — 12.65 = 1.55 lb. per sq.in., which gives a loss of 1.55 × 1.07 = 1.66 hp. The engine friction per cylinder end, as previously found, is 11.13, from which the maximum delivered horsepower is found to be 105 — (1.66 + 11.13) = 92.21. If the maximum developed horsepower of the engine is 92.21 per cylinder end, and 10 per cent. overload capacity be allowed, the rated load per cylinder end will be 92 ÷ 1.10 = 83.6 developed horsepower.

Assume the mechanical efficiency to be 86 per cent. for full load and check as follows: 83.6 ÷ 0.86 = 97.3 i.hp. From Fig. 2 the loss due to the suction stroke for 97.3 i.hp. is 2.1 lb. per sq.in., which gives 2.1 × 1.07 = 2.25 hp.; therefore the total loss will be 2.25 + 11.13 = 13.38 hp.; and 83.6 + 13.38 = 96.98 i.hp., which checks very closely with 97.3, as assumed in the foregoing.

The developed horsepower for several values of indicated horsepower was found in the manner described, and from the results the mechanical efficiency was calculated. The value of indicated horsepower, developed horsepower, and mechanical efficiency are given in the table.

CALCULATED VALUES OF DELIVERED HORSEPOWER AND MECHANICAL EFFICIENCY

Per Cent. Load	Indicated Horsepower	Delivered Horsepower	Mechanical Efficiency, Per Cent.
0	20.00	00.0	00.0
25	39.28	20.9	53.5
50	58.00	41.8	72.0
75	77.30	62.6	81.0
100	97.30	83.6	86.0
110	105.00	92.0	87.5

The mechanical efficiencies calculated agree closely with the average value for machines of this type, and while the assumption that machine friction is constant for all loads is not true, it is believed that the error in this case is so small that it can be safely neglected.

The author in the paper has also treated the theoretical development, embracing an outline of the method, amount of mixture required, pressure in the cylinder during suction stroke, port areas, and also the method of determining the value of N in the equation $P_1V_1{}^N = P_2V_2{}^N$.

In the conclusion it is stated that the work has been done to find out as nearly as possible the conditions under which the charge enters the cylinder of a throttling gas engine and

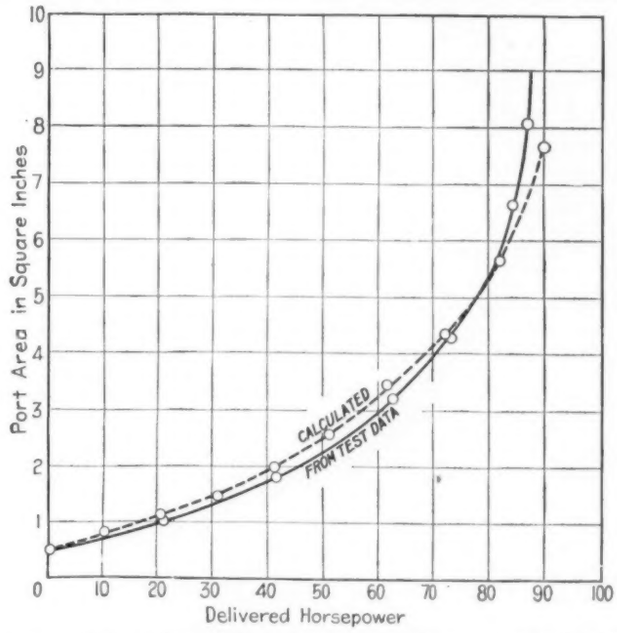


FIG. 3. RELATION BETWEEN DELIVERED HORSEPOWER AND PORT AREA

to suggest a method of supplying for any load the amount of charge that will tend to make the engine regulate with the same degree of sensitiveness throughout the full range of load. In Fig. 3 there are two curves showing the relation between delivered horsepower and port area; one is based on test data, and the other is plotted from calculated data for the same engine. From these curves and the characteristic curve of the governor to be used, the relation between the travel of the governor collar and port area can be determined and a governing mechanism designed that will give equal changes in load for equal movements of the governor collar. Another way of obtaining the same result would be to so shape the ports that equal changes in governor-collar travel would give equal movements to the valve, but at the same time give the proper port area for equal changes in power delivered. It is possible that for other fuels and types of engines the constants used in working out the foregoing problem may differ slightly, but it is believed that the method can be applied to any case with satisfactory results.

Sixty-Inch Centennial Belt

Among the exhibits at the Centennial Exposition of 1876 was a 60-in. double leather belt, 187 ft. long, shown by J. B. Hoyt & Co., of New York. This was the widest and largest leather belt that had ever been made, and was intended for the Augustine mills of the Jessup & Moore Paper Co., of Wilmington, Del., to whom it was delivered early in 1877.

This belt transmitted 650 to 700 hp., traveling over a 24-ft. diameter pulley on the engine to a 9½-ft. pulley on the line-shaft, at an engine speed of 52 r.p.m., or a belt speed of 3920 ft. per minute, or 44.5 miles per hour. This mill operated continuously, starting at midnight Sunday and continuing in operation until midnight the following Saturday, so that the belt ran 24 hours per day, and averaged 300 days per year.

In 1902 the old belt had run 25 years, and in that time had traveled 8,010,000 miles, but its usefulness was by no means over. It always ran under damp conditions, because of its proximity to water, but notwithstanding these unfavorable conditions, when in 1902 it was sent to the factory to be cut into a 36-in. and other sizes, it was not rebuilt and there were no material repairs made upon it, and the same cement that was applied in 1876 is today holding the 36-in. belt together, and it has satisfactorily transmitted 350 hp., equivalent to a working load of 198 lb. per sq. in. plus tension, from 1902. It is still running 144 hours per week, with prospect of several years more of usefulness in its present position. When the time comes to replace it, it will be possible to cut it up into smaller belts, which will probably be used successfully for many years in places where the performance is less exacting in its requirements, and these again, when their days of usefulness in the particular duty assigned them is over, may be cut into still smaller belts, and so on, and the final remains will have a value for heels and washers.

The longevity of this belt is not due to the lightness of its load, for its maximum transmission of 700 hp. is equivalent to a working stress of 262 lb. per sq.in., plus its tension—no small load; nor has it been due to superior care.

This belt, now operating over a 16-ft. engine pulley at 82 r.p.m. to a 6-ft. pulley on the mainshaft, has a belt speed of 4122 r.p.m., equivalent to 46.8 miles per hour, and in its present position in 15 years it has traveled 5,256,576 miles, which added to the distance which it traveled as a part of the 60-in. belt, equals a total of more than 13,266,576 miles with a considerable addition to be made to these figures by its subsequent performance.

This belt, 187 ft. long, probably cost originally about $1250. There has been expended upon it practically nothing for repairs, and the cost of transmitting 650 to 700 hp. for 25 years, and 350 hp. for 15 years, to say nothing of the transmission by the smaller belts cut from the original belt, has cost $75 per annum for interest, and the amortization of the original cost will be completed at an annual cost of about $31, a total cost of about $106 per annum; or disregarding the service rendered by the smaller belts, and averaging the loads with the years of service of the 60- and 36-in. belts at 570 hp., this power has been transmitted at a cost of about 18c. per horsepower per annum, and when the story is finally closed this insignificant cost will be further reduced.

Chairman Peabody on Coal Production

Following is an abstract of a circular letter addressed to the coal operators of the United States by F. S. Peabody, Chairman, Committee on Coal Production:

The country at the present time in the matter of its fuel production is confronted with a great emergency. Notwithstanding the increased production of coal from practically every district, the increasing requirements to meet the needs of all classes of industry, as well as for the comfort and welfare of the people and the transportation of troops, munitions, food and other products, together with the supplying of our allies, and for our national protection—all these demands are liable to surpass the capacity of our mines unless the full coöperation of the mining, transporting and distributing agents of this country is secured. This emergency requires not only the development of the highest efficiency, especially on account of a diminished supply of labor used in the production of coal, but also in more comprehensive methods of coöperation by the coal producers with the transporting and distributing agencies. If the demand continues to increase, it may be necessary that active steps be taken to so far as possible confine the distribution and use of it to those activities which are more nearly vital to the welfare and protection of the nation. That this may not effect an unnecessary hardship upon the domestic welfare of our people we urge upon you that you coöperate with this committee in its efforts to promote the largest production, the most equitable distribution and the highest use to produce the best economic results and it is the belief of this committee that with your hearty support and the assistance of the public in conserving the supply, sufficient fuel can be had to meet public necessity.

The total production of coal throughout the country has been seriously curtailed by difficulties in transportation service and unequal distribution of cars, resulting in shortage in the number of cars available for loading, as well as congestion in the avenues leading to the points of distribution. We urge upon the operators that they pledge themselves to load all cars obtainable in the shortest time after the same become available, and that they further take up and urge their customers to release these cars at the earliest possible date after delivery so as to make them available for further use without unnecessary delay, and that all practices such as unnecessary holding of cars for reconsignment or other purposes be discontinued except when absolutely necessary for the public welfare. We urge distributing interests, especially in the centers of large population, in so far as is possible to deliver coal to their customers along normal and ordinary lines to avoid creating panic. We urge in turn upon all such distributors that information be sent to this committee of conditions in such cities as may be benefited by a closer coöperation of all concerned in our effort to supply all communities with their requirements.

If it is found that in any districts surplus coal is obtainable at this time over and above the actual needs, it should be divided and stored in the bins of the ultimate consumer so that normal operation may be continuous and tend to prevent the hardships which result from an unequal distribution of coal. The centralization in the operation of our transportation lines has proved of the greatest benefit to the coal industry and we believe that a like centralization secured through the coördination of all interests will promote a still higher efficiency and be of greater benefit to producer as well as consumer.

Third Annual Convention A. A. E.

On the evenings of May 14 and 15 the American Association of Engineers held its third annual convention at the City Club, Chicago. The principal business conducted was the nomination of officers for the ensuing year and the discussion of proposed changes in the constitution. The first evening was given over to the annual banquet, military talks by officers in the service and an address by Gardner S. Williams on the "Engineers' National Coöperative Business Organization."

Mr. Williams reviewed the status of engineering in America today and compared the situation existing with that of the three learned professions; the law, medicine and the clergy. He proposed an organization of engineers such as has been built up by the American Medical Society. Coöperation here is the watchword and similarly coöperation is the solution for engineers. Starting with the county medical society as a unit, to which every practitioner in the county is supposed to belong, there next comes the State Medical Society to which the county societies send representatives, and this in turn sends its delegates to the American Medical Society. Every physician in the country is thus within call of the head of the organization in the National Society. The Chamber of Commerce of the United States has accomplished a similar purpose with the local business organizations without the intervention of the state society. The Bankers Association follows the plan of the physicians.

For the engineer, inasmuch as the state societies are rarely as strong as some of the local societies within the same territory, it would not seem necessary to go from the local to the national organization by way of the state society as an intermediary, but more rational to unite all national, state and local societies in a combination, to the governing body of which each would send delegates in proportion to its membership.

The great national engineering societies of the country have in embryo an organization well adapted to this purpose in the Engineering Council and if they can be brought to see the advantages to come from an extension of it beyond the limits of their own membership, there should be little difficulty in gathering into the combination the 90,000, more or less, engineers now affiliated with the national, state and local societies. There would then come the great army of more than equal size which until recently was wholly unorganized and among whom the American Association of Engineers has its greatest field.

It was Mr. William's opinion that the engineer should look to the national societies to take their place as leaders in bringing about complete coöperation of engineers.

The speaker believed that if the national societies failed to meet their responsibilities and after a reasonable time did not work out a plan of coöperation involving the utilization of all engineering forces of the commonwealth, then it would be time to turn to other agencies and the possibilities of the American Association of Engineers would be entitled to the most serious consideration.

On Tuesday and the following Friday evenings the proposed changes in the constitution drawn up by a committee previously appointed, were considered. The final result was the appointment of another committee to draw up a third constitution so that there would be two revised constitutions to present to the members for action. Likewise two slates of officers were nominated and the choice will be made by letter ballot.

ENGINEERING AFFAIRS

Professional Classes War Relief Council—Lewis B. Stillwell, 100 Broadway, New York, has received a letter from Major Leonard Darwin, chairman of the Professional Classes War Relief Council of Great Britain, in which he expresses, in behalf of the Council, appreciation of the contributions of American engineers to this fund. The Farmers' Loan and Trust Co., under date of May 11, advises that the subscriptions to date aggregated $11,793.25. This sum has been contributed by 1154 engineers, and it is to be hoped that, in view of the fact that we are now actually at war as allies of our British friends, those who have not hitherto contributed will act promptly in aid of this worthy and urgent cause.

The Chicago Section, A. S. M. E., on Friday evening, May 18, held its last meeting of the season. It was ladies' night for the first time in the history of the organization. The attendance was unusually large and the social success of the gathering so pronounced that it was the unanimous opinion that there should be more of such meetings. S. J. Duncan-Clark, war analyst of the "Chicago Evening Post," was the speaker of the evening, his topic being "The World War Situation of Today." To give the audience the proper perspective the incidents leading up to the great conflict were reviewed and the situation on each front most ably analyzed. As a mark of appreciation the hat was passed and the sum of $45 was turned over to the Chicago Section of the Red Cross. The following officers were elected for the ensuing year: A. D. Bailey, chairman; H. T. Bentley, vice-chairman; Arthur L. Rice, secretary; G. R. Brandon and P. N. Engel, members of executive committee.

The Combined N. A. S. E. Associations of Brooklyn, N. Y., held a get-together meeting on Saturday, May 19, at the Operating Engineers' Building, 125 South Elliott Place. The main meeting hall was tastefully decorated. The attendance was the largest that ever crowded itself into the building, there being delegations from New Jersey and the entire Metropolitan district, including many of the prominent folks in the operating engineering field. The festivities opened with the "Star Spangled Banner," after which Frank Martin, of Jenkins Bros., introduced the following speakers: William Downey, who talked on "Our State Organization"; George O. Kaley, "The Combined Brooklyn Organizations"; John B. McGowan, "The Obligations of Membership"; Joseph F. Carney, "The Future of the N. A. S. E."; John J. Callahan, "State Legislation"; James R. Coe, "Our Preamble"; William J. Reynolds, "The National Engineer"; Frederick Felderman, "Extension Work"; James D. Taylor, "Life and Accident"; Charles H. Bromley, "Figures on the Magnitude of the War"; John J. Reddy, "Organization Work"; P. Cassidy, "Educational Work." During the evening an enjoyable entertainment was furnished by Bert Self, Peerless Rubber Manufacturing Co.; J. J. Canton, Joe McKenna and Billy Murray, Jenkins Bros.; and Jack Armour, of "Power." Instrumental music by Messrs. Cæsar, Schmidt, Mahar and Schuback. Refreshments were plentifully served at intervals.

The American Institute of Electrical Engineers held its annual business meeting in the auditorium of the Engineering Societies Building on Friday evening, May 18, with President H. W. Buck in the chair. The report of the board of directors for the fiscal year ended Apr. 30, 1917, in which was included a detailed statement of the financial status of the institute and a summary of the work accomplished by the standing committees during the year, was presented by Secretary F. L. Hutchinson, who also read the report of the committee of tellers on the election of officers for the coming administrative year. The following were elected: President, E. R. Rice, Jr., Schenectady, N. Y.; vice presidents, Frederick Bedell, Ithaca, N. Y., J. H. Finney, Washington, D. C., and A. S. McAllister, New York; managers, W. A. Del Mar, New York; W. A. Hall, West Lynn, Mass.; E. H. Martindale, Cleveland, Ohio; and Wilfred Sykes, Pittsburgh, Penn.; treasurer, George A. Hamilton, Elizabeth, N. J. After the business meeting, the seventh Edison Medal, which was awarded to Nikola Tesla on Dec. 13, 1916, for meritorious achievement in his early original work in polyphase, high-frequency and high-potential alternating currents, was presented to Mr. Tesla. President Buck introduced Dr. A. E. Kennelly, who told of the origin and purpose of the Edison Medal, after which C. A. Terry and B. A. Behrend gave addresses on the history of Mr. Tesla's patents and his contributions to the arts. The medal was presented by President Buck, and the ceremonies concluded with a response from Mr. Tesla.

PERSONALS

John G. Barry, manager of the railway department of the General Electric Co., has been appointed general sales manager of the company.

Siegfried Rosenzweig, formerly mechanical engineer with the Erie City Iron Works, and more recently consulting engineer of the steam-engine department of the York Manufacturing Co., York, Penn., has joined the American Spray Co., 26 Cortlandt St., New York City, in a similar capacity.

Horace H. Judson, for years connected with the Nonpareil Cork Manufacturing Co., later as superintendent of construction in the East with the Armstrong Cork Co., and more recently superintendent of construction with the H. W. Johns-Mansville Co., has resigned to become associated with Junius H. Stone, formerly president of the Nonpareil Cork Manufacturing Co., who has opened a cold-storage insulation business for himself at 461 Eighth Ave., New York City.

Prof. Charles R. Richards has been appointed dean of the College of Engineering, University of Illinois, to succeed Dean W. F. M. Goss. Dean Richards graduated from Purdue in 1890 and the following year he was instructor in mechanical engineering in the Colorado Agricultural College. For the next 19 years he taught engineering at the University of Nebraska, and was dean of the College of Engineering there when he left in 1911. In that year he became professor of mechanical engineering at Illinois. In 1913-15 he served as acting dean of the college during the absence of Dean Goss, and also held the position for a few weeks this spring.

BUSINESS NOTES

The Casey-Moorhead Engineering Co. has opened an office in the Bessemer Building, Pittsburgh, Penn., as consulting electrical engineers. Messrs. Moorhead and Casey were formerly with the Westinghouse Electric and Manufacturing Co.

Duquesne Electric and Manufacturing Co. is the new name recently adopted by the Service Supply and Equipment Co., Bessemer Building, Pittsburgh, Penn., as specialists on new and second-hand electrical equipment and electrical repair work. The company has opened a large repair shop at East Liberty, Penn.

The S K F Administrative Co., of 1 Wall St., New York City, a corporation recently formed, will hereafter administer the affairs of the S K F Ball Bearing Co. and the Hess-Bright Manufacturing Co., thus perfecting a closer coöperation between the two concerns. B. G. Prytz, who was president of the S K F Ball Bearing Co., has been elected president of the Administrative company. Budd D. Gray, who was president of the Hess-Bright Co., at Philadelphia, has resigned to become technical adviser of the New York corporation.

Resistance of An Oil to Emulsification

A new publication of the Bureau of Standards (Technologic Paper No. 86) entitled "Resistance of an Oil to Emulsification," is ready for distribution. When oil is used over and over again, as is the usual practice in large power plants, it may emulsify in a few days if it is not good quality, and have to be thrown away, as it will not pass through the filters. To avoid the waste of time and the inconvenience of actually trying the oil in a turbine or other machine, a laboratory test has been devised by means of which it may be predicted whether or not the oil would give satisfaction in service. The test consists of violently stirring a small sample of the oil with water under standard conditions. Then the oil that will separate out from the water the most rapidly is the best oil for turbine lubrication, other things being equal. It is found that most of the oils on the market are either very bad or very good, and that there is no difficulty in finding turbine oils that will settle out from the water in a minute or less after stirring as described. For some other purposes it is desirable that oils should emulsify readily, and the test shows that oils of this class, when subjected to the same treatment as the turbine oils, will not separate at all in one hour, nor completely separate in one year. When turbine oils are used for months or years without renewal, they gradually deteriorate until they emulsify readily, even though they are very good oils to start with. The conditions of use in different plants are so different that it would be impossible to predict just how long a given oil would last, but it is believed that any power-house engineer, by the use of this test, could keep track of the deterioration of his oil and thus discover when it is time to clean out his lubricating system.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	May 26, 1917	One Year Ago	May 26, 1917	One Year Ago
Buckwheat	.....	$2.05—3.20	$6 00—6.75	$3 25—3.50
Rice	.....	2.50—2.65	5.20—5.85	2.70—2.95
Boiler	.....*	.....	.....*	.....
Barley	.....[1]	2.20—2.35	4 90—5.00	2.35—2.60

*No prices quoted

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	May 26, 1917	One Year Ago	May 26, 1917	One Year Ago
Clearfields	$5.75—6.50	$1.15—1.60	$10.75—11.25	$4.25—5.00
Cambrias and Somersets	6.00—6.75	1 40—1.75	11.00—11.50	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $7.50—8.50, as compared with $2.75—2.85 a year ago; on cars Boston price is $13.

*All-rail rate to Boston is $2 60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	May 26, 1917	One Year Ago	May 26, 1917	One Year Ago
Buckwheat	$4.00—4 15	$2.75	$5.75—6.00	$2.65—2.75
Rice	3.40—4.05	2.25	4.50—4.75	2.20—2.25
Barley	2.90—3.10	1.75	3.50—3.75	1.70—1 75

BITUMINOUS

	South Amboy	Port Reading	Mine Price
Clearfield	$7.25—7.50	$7.25—7.50	$5.25—5.75
South Forks	7 25—7.50	.....	5.25—5.75
Nanty Glo	7.25—7.50	.....	5.25—5.75
Somerset	7.00—7.25	7.00—7.25	5.00—5.50
Quemahoning	7.25—7.50	7.25—7.50	5 25—5.75

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	May 26, 1917	One Year Ago	May 26, 1917	One Year Ago
Buckwheat	$2.80	$1.65	$3.70	$2.55
Rice	2.30	.90	3.30	1 80
Boiler	2 10	....	3 20	....
Barley	1.80	.55	2.05	1.30

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	May 26, 1917	One Year Ago
Slack	$4.75—5.00	$0.95—1.05
Mine-run	4.75—5.00	1.30—1.40
¾-in.	4.75—5.00	1.40—1.50

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current price per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump	$3.00—3 50	$3.25—4.00	$6.00—6 50	$3.25	$3.50—3.75
Lump	3.25—3.75	3.25—4.00	6.00—6.50	3.25	3.75—4.00
Egg	3 25—3.75	3.25—3.75	6 00—6.50	3.25	3.75—4.00
Nut	3.25—3.75	3.25—3.75	.....	3.25	3.75—4.00
No. 1 nut	3.25—3 75	3.25—3.75	.....	3.25	3 75—4.00
No. 2 nut	3 25—3.75	3.25—3.75	.....	3.25	3.75—4.00
No. 3 nut	3.00—3.75	3.00—3 50	.....	....	.....
No. 1 washed	3.25—3.75	.....	.....	....	.....
No. 2 washed	3.25—3.75	.....	.....	....	.....
Mine-run	2.75—3 50	2.75—3 50	5.50—6.00	3.25	3.50—3.75
Screenings	2.75—3.50	2.75—3.50	.....	3.25	3.50—3.75

Hocking lump, $4.50—4.75; splint lump, $4.00—4.75.

St. Louis—Prices per net ton f.o.b. mine a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	May 26, 1917	One Year Ago	May 26, 1917	One Year Ago	May 26, 1917	One Year Ago
6-in. lump	$3.25	$1.40	$2.25	$1.35	$1 90	$1.15
2-in. lump	3.25	1.25	2.25	1 20	1.75	.95
Steam egg	3.25	1.25	2.25	1.20	1.75	.95
Mine-run	3.00	1.25	2.25	1.10	1 75	.95
No 1 nut	3.25	1 40	2 25	1 20	2.00	1.10
2-in. screen	2.75	1.40	2.00	1.20	1.75	1.10
No. 5 washed	2.75	1.40	2.00	1.20	1.75	1 00

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run		Mine-Run
Pratt	$4.00	Carbon Hill	$3.50—3.75
Big Seam	3.25—3.50	Cahaba	4.00
Black Creek	4.00		

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ala., Dothan—T. M. Espy and W. L. Lee are reported interested in a hydro-electric development here.

Ark., Ozark—City is having plans prepared for improvements to the electric-light plant. A. Littleton, Mgr.

Cal., Rialto—L. S. Keith, Fontana, will soon receive bids for a 40 x 50-ft. reinforced concrete power house to be erected in Lytle Creek Canyon, about 5 mi. north of here, for which, R. D. Johnson, Staas Co. Bldg., Pasadena, Arch., has prepared the plans.

Calif., Vallejo—(Official)—Bureau of Supplies and Accounts, Navy Dept., Washington, will receive bids June 5 for furnishing under Schedule 1133 at Mare Island Navy Yard, 2½-in. suction, and 2½-in. discharge plunger-type pumps.

Conn., Hartford—The Hartford Rubber Works have been granted a permit for a 24 x 25-ft. concrete boiler house, in connection with its plant on Bartholomew Ave.

Ill., Chicago—The Central Manufacturing Co., 1st National Bank Bldg., will construct a power station at 2015 West 39th St. Estimated cost, $250,000. S. Scott Joy, Arch.

Ill., Paris—Bd. of Local Improvements plan to install an electric-lighting system in the business district.

Ind., Winona Lake—The Indiana Public Service Comn. has granted permission to the Winona Electric Light and Water Co. to issue $85,000 bonds to improve its system and for other purposes. A. G. Menzie, Warsaw, Engr. of Power Station.

Ia., Burlington—The Burlington Railway and Light Co. will erect several transmission lines during year, including line to connect Burlington with Mediapolis, Morning Sun, Wapello and Winfield; also line from Burlington to Middletown. The energy will be supplied from the plant at the Keokuk dam to the cities and towns north of Burlington. D. D. Bentzinger, 4th and Market St., Supt. and Pur. Agt.

Ia., Ft. Dodge—The Ft. Dodge, Des Moines & Southeast Electric Ry. Co. plans to spend $250,000 on improving and extending its plant. G. H. Crowne, Gen. Mgr.

Ia., Little Rock—The city has issued $15,000 bonds to install an electric-light plant.

Kan., Arcadia—City plans to install an electric distribution system.

Kan., Marysville—The Marysville Light, Power and Water Co. is considering extending its distribution system. C. J. Garvin, Engr. of Power Station.

Kan., Toronto—City plans to install a light plant. Estimated cost, $15,000. W. B. Rollins & Co., 209 Railway Exchange Bldg., Kansas City, Mo., Engr.

Ky., Lothair—The Kentucky River Power Co., Hazard, plans to install transmission lines into Lott's Creek field to furnish electricity to the coal-mining companies in that district. J. M. Watson, Hazard, Ch. Engr. Power Station.

Mass., Boston—(Official)—Bureau of Supplies and Accounts, Navy Dept., Washington, will receive bids June 5 for furnishing under Schedule 1133 at the Navy Yard, Boston, 2-in. suction, 2-in. discharge, plunger-type pumps.

Mich., Benton Harbor—Mercy Hospital will soon receive bids for 30 x 40-ft. heating plant.

Mich., Monroe—The City Comn. granted franchise to the Detroit Edison Co. to purchase the municipal electric-light plant and furnish electrical service here. New plant will be constructed.

Mo., Kansas City—The Kansas City Railways Co. will construct a 1-story substation. Estimated cost, $7000. E. E. Stigall, 1500 Grand Ave., Pur. Agt.

Neb., Greeley—P. A. Johansen, Anita, is reported to be interested in the project of constructing an electric-light plant in Greeley.

N. J., Perth Amboy—The Bd. of Aldermen approved of a $50,000 bond issue for the completion of the commercial system of the municipal electric-light plant. F. Garretson, Mayor.

N. Y., New York—(Official)—Bureau of Supplies and Accounts, Navy Dept., Washington, will receive bids June 5 for furnishing under Schedule 1133, at the Brooklyn Navy Yard, 3½-in. centrifugal, horizontal pumps.

N. Y., New York—(Official)—Bureau of Supplies and Accounts, Navy Dept., Washington, will soon receive bids for furnishing under Schedule 1136, complete heating and ventilating set and 3 complete ventilating sets.

N. Y., New York—Bureau of Supplies and Accounts, Navy Dept., Washington, will soon receive bids for furnishing under Schedule 1156 at Navy Yard, Brooklyn, thermometers, common, mercurical, mechanical, storage battery, etc.

N. Y., Poughkeepsie—The Poughkeepsie & Wappingers Falls Electric Ry. Co. increased its capital stock from $750,000 to $1,000,000, and will improve its plant. C. A. Brooks, 493 Main St., Local Mgr.

Ohio, Salem—The Salem Lighting Co. will extend and improve its plant, including the installation of new boiler equipment, to cost about $10,000.

Wash., Index—The City Council has passed an ordinance to construct an electric-light and power plant. G. N. Miller, Engr., Seattle, will have charge of the work.

W. Va., Bluefield—The Appalachian Power Co., Bluefield, will construct an electric transmission system between Norton, Esserville, Wise and other towns in this section. M. McCormick, Bluefield, Pur. Agt.

Wis., Marshfield—E. Brielmaier & Sons, 41 University Bldg., Milwaukee, Arch., is receiving bids for a power house at St. Josephs Hospital, Marshfield.

Wis., Racine—The Milwaukee Electric Railway and Light Co. is having plans prepared for a brick and steel addition to its power house. Estimated cost, $25,000. F. V. Bentz, Public Service Bldg., Milwaukee, Pur. Agt.